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CHIEF OF ORDNANCE, U. S. ARMY.

ANNUAL REPORT

OF THE

CHIEF OF ORDNANCE

TO THE

SECRETARY OF WAR

FOR THE

FISCAL YEAR ENDED JUNE 30, 1875.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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REPORT

OF

THE CHIEF OF ORDNANCE.

ORDNANCE OFFICE, WAR DEPARTMENT,
Washington, October 9, 1875.

SIR: I have the honor to submit the following report of the principal operations of the Ordnance Department during the fiscal year ended June 30, 1875, with such remarks and recommendations as the interests of that branch of the military service seem to require.

The fiscal resources and disbursements of the Department during the year were as follows, viz:

Amount of appropriations in Treasury June 30, 1874	$1,434,105 88
Amount in Government depositories to credit of disbursing officers on same date	468,268 10
Amount of deposits in Treasury not reported to the credit of the appropriations on the same date	4,318 38
Amount of appropriations from July 1, 1874, to June 30, 1875, including the fixed annual appropriation for arming and equipping the militia.	1,342,457 00
Amount of appropriation for the year 1876 available for Rock Island Arsenal, during the fiscal year ending June 30, 1875	100,000 00
Amount from appropriation from sales of ordnance material	56,000 00
Amount (net) received since June 30, 1874, on account of damages to arms in hands of troops, from sales of arms to officers, and of condemned stores, and from all other sources not before mentioned	849,438 72
Total	4,254,578 08

Amount of expenditures since June 30, 1874	1,984,849 89
Amount reported as in the Treasury June 30, 1874, not carried to the appropriations, now covered in as miscellaneous receipts on account of sales of ordnance stores	1,400 20
Amount deposited under appropriation for allowance under eight-hour law in excess of remittances	8,026 74
Amount deposited in Treasury during the fiscal year ending June 30, 1875, as miscellaneous receipts	790,351 10
Amount of deposits in Treasury not reported to the credit of the appropriation on June 30, 1875	11,686 24
Amount in Government depositories to the credit of disbursing-officers on June 30, 1875	255,709 26
Amount turned in to the "surplus fund"	940,019 77
Amount of appropriations in Treasury June 30, 1875	262,534 88
Total	4,254,578 08

During the past year all the varied duties of the Department and the operations at the several arsenals and the National Armory have been performed with a view to an economical expenditure of the limited appropriations made and an efficient and successful administration of the Department. The erection of public buildings at the Rock Island and Benicia Arsenals under specific appropriations; the manufacture of arms ammunition, equipments, and other ordnance stores and supplies, and their distribution to the Army, militia, and Marine Corps; the examination and testing of inventions, and experiments and trials with heavy cannon at the proving-grounds at Sandy Hook; and the care and preservation of the different arsenals and of their stores and supplies, have given full occupation to the officers of the Corps.

REPAIRS OF ARSENALS.

The very small appropriation made the past few years "for the repairs of the smaller arsenals, &c., $50,000," is deemed entirely inadequate to the proper care and preservation of these government establishments, and, as a consequence, the public buildings, inclosures, &c., that need constant and careful attention, are in many cases going to ruin and decay. It is not judicious economy, for want of a moderate present expenditure, to permit such valuable properties to be injured almost beyond the power of renovation. The arsenals inclose within their limits from ten to fifty buildings each, with extended walls or fences as inclosures, miles of roads and sewers, and in some of them river walls and wharves, making an aggregate of perishable structures and improvements that call for a liberal appropriation for their care and preservation.

ARMING AND EQUIPPING THE MILITIA.

At the instance of this Bureau, for the purpose of relieving many of the States and Territories from charges of arms, &c., on the books of this Office, Congress passed the following at its last session:

[Extract from "An act making appropriations, &c., for the support of the Army for the fiscal year ending June 30, 1876, and for other purposes," approved March 3, 1875.]

"SEC. 3. That all issues of arms and other ordnance stores which were made by the War Department to the States and Territories between the first day of January, eighteen hundred and sixty-one, and the ninth day of April, eighteen hundred and sixty-five, under the act of April twenty-third, eighteen hundred and eight, and charged to the States and Territories, having been made for the maintenance and preservation of the Union, and properly chargeable to the United States, the Secretary of War is hereby authorized, upon a proper showing by such States of the faithful disposition of said arms and ordnance stores, in the service of the United States in the suppression of the war of the rebellion, to credit the several States and Territories with the sum charged to them respectively for arms and other ordnance stores which were issued to them between the aforementioned dates, and charged against their quotas under the law for arming and equipping the militia: *Provided*, That it shall be the duty of the Secretary of War, before making a credit to any of said States and Territories, to investigate and ascertain, so nearly as he can, the disposition made by each of said States and Territories of said arms and ordnance stores; and, if he shall find that any of said arms or ordnance stores have been sold or otherwise misapplied, to refuse a credit to such State or Territory for so much of said arms and ordnance stores as have been sold or misapplied; and the amount thereof shall remain a charge against said State or Territory, the same as if this act had not been passed."

In the endeavor to properly carry out the intention of this law a circular letter has been sent to the governors of such States and Territories as are interested, giving the law above quoted, and inclosing a detailed statement, taken from the books of this Office, of all issues made between the dates fixed in the law and charged against their quota under the act of April 23, 1808, for arming and equipping the militia. They have been requested to cause a detailed statement to be made to this Office at an early day, supported by the necessary vouchers or other satisfactory evidence, showing—

I. The disposition made of the particular arms, &c., received between the aforementioned dates. If issued to State troops who were subsequently mustered into the service of the United States, *carrying with them these arms, &c.*, the name of the company and regiment (in the United States service) of such troops must be stated, together with the name of company and regimental commander, and the date and place of muster-in and muster-out.

II. If any of such arms and ordnance stores at any time up to present date reverted to the possession of the State, the disposition of the same by the State authorities must be stated.

III. If any arms or other ordnance stores, now charged against your State, were lost or destroyed during the rebellion, their description and quantity must be stated, the cause and manner of their destruction given, and properly supported by evidence, with the reasons why credit should be given by the United States for said loss.

But few of the States and Territories have responded to this circular letter, but this Bureau will renew its efforts to reach a satisfactory and final solution of this matter, so necessary to the proper arming and equipping of the militia.

It is recommended that the attention of Congress be invited to the following:

"AN ACT to authorize and direct the Secretary of War to distribute arms and military equipments under the act of April twenty-three, eighteen hundred and eight, and the acts amendatory thereof.

"*Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled*, That the Secretary of War be, and he is hereby, authorized and directed to distribute to such States as did not, from the year eighteen hundred and sixty-two to the year eighteen hundred and sixty-nine, receive the same, their proper quota of arms and military equipments for each year, from eighteen hundred and sixty-two to eighteen hundred and sixty-nine, under the act of Congress approved April twenty-third, eighteen hundred and eight, and the several acts amendatory thereof: *Provided*, That in the organization and equipment of military companies and organizations with said arms no discrimination shall be made between said companies and organizations on account of race, color, or former condition of servitude."

"Approved March 3, 1873."

Under the provisions of this act all the States that had been in rebellion were credited on the books of this Office with their respective quotas during the period mentioned, and arms and other ordnance stores were issued to several of them on their application, and charged accordingly. At the last session, however, Congress passed the following:

Extract from "An act making appropriations, &c., for the support of the Army for the fiscal year ending June 30, 1876, and for other purposes," approved March 3, 1875.

"*And provided further*, That so much of the appropriations between the first of January, eighteen hundred and sixty-one, and the ninth of April, eighteen hundred and sixty-five, under the act of April twenty-third, eighteen hundred and eight, herein referred to, as would have been used for the purchase of arms to be distributed to the several States that were in rebellion, shall be covered into the Treasury of the United States."

The effect of this last act is to annul the provisions of the act above quoted, approved March 3, 1873, and in its consequence to do injustice to some of the States interested by an unequal distribution of stores. So much of the appropriations referred to as was still to the credit of any of these States has been "covered into the Treasury of the United States;" but it is suggested whether, in consideration of the two laws above quoted, and the interests of the militia of the States, Congress should not be asked for further legislation thereon.

This Bureau has, for several years past, called attention to the necessity of an increase to the annual appropriation for arming and equipping the militia. The subject has been discussed in previous reports, and a mere reference to its importance to the interests of the whole country is now made. The annual appropriation of $200,000 was made in 1808, when the population of the country was about eight millions. At the present time, with a population of over forty millions, the amount appropriated is still the same, and it is impossible for this Department to meet all the demands made upon it by the States and Territories. If it be the intention and desire of Congress, as expressed in the act of 1808, to provide "arms and military equipments for the whole body of the militia of the United States," then the necessary means ought to be supplied by largely increasing the annual appropriation. The last official reports give the following as the aggregate strength of the militia of the United States:

Organized	84,724
Unorganized	3,701,977

and there is little doubt that were "arms and military equipments" more freely supplied, the organized force would be greatly enlarged. The hope is entertained that this may receive the attention of the proper committee, and that further legislation may be had at the next session of Congress.

ARSENALS.

Congress, at its last session, in "An act making appropriations for sundry civil expenses of the Government for the fiscal year ending June 30, 1876, and for other purposes," provided as follows:

"And the Secretary of War is hereby directed to cause an examination to be made into the condition of the United States arsenals east of the Mississippi River, and to report to the next Congress how many of the same can be sold without interfering with the necessities of the military service, together with an estimate of the amount that can probably be realized from the sale of each of the same whenever such sale shall be directed by Congress."

In pursuance thereof, a board, consisting of Lieutenant-Colonel Crispin and Majors Treadwell and Baylor, Ordnance Department, was appointed for the purpose indicated, and its report is herewith submitted, (marked "Appendix A.")

The board recommends the immediate sale of Pikesville Arsenal, Md. This recommendation is concurred in, the arsenal being badly located and of insufficient capacity for storage to justify the expenditures necessary to keep it in repair. The Detroit Arsenal having been recently turned over to the Interior Department for sale, as required by law, and the Columbus Arsenal having been transferred to the general recruiting service for depot purposes, the board strongly recommends the retention of all the remaining arsenals east of the Mississippi as essential for the necessities and proper service of the Ordnance Department, unless Congress shall by legislative enactment permit the execution of the plan of concentration proposed by the board on arsenals in 1874. (See Chief of Ordnance Report, 1874.)

That plan consists in the establishment of a grand arsenal of construction in the vicinity of New York City, retaining the Springfield Armory and the Frankford Arsenal as adjuncts, for manufacturing purposes; retaining, also, the Indianapolis Arsenal, Ind.; Kennebec Arsenal, Me.; Fort Monroe Arsenal, Va., and Augusta Arsenal, Ga., as places for storage and repair; and selling the Allegheny, Watervliet, Watertown, and Washington Arsenals as rapidly as circumstances will permit, the proceeds of such sales to be devoted to the purchase of a site and the erection of workshops, store-houses, &c., for the grand arsenal. The amount that can probably be realized from the sales will be $3,316,824.56.

The wisdom and economy of a greater concentration of ordnance manufactures seem to call for no extended argument. The military powers of the world do not fritter away their means in fostering numerous establishments, but bring together in one grand whole all their resources, that there may result economy and perfect work. The experience of all private enterprises points to concentration as a vital element of success. Proximity to the raw material, skilled labor, and cheap transportation are the scarcely less important factors in the problem, and all these can be attained by the plan proposed. It appeals all the more strongly for favorable consideration and action, in that the plan can be carried out without taking a dollar from the public treasury. This policy of concentration has been carried out for the Pacific coast at the Benicia Arsenal, and for the Mississippi Valley at the Rock Island Arsenal, and cannot be too highly commended nor too closely followed.

With our railroad system of intercommunication that reaches every portion of our broad domain, the distance to any point of our long shore-line, or of our vast inland frontier, is becoming of less paramount importance in the distribution of war material, and a few well-selected and amply-provided centers of supply can more quickly and economically fulfill all demands than did the many arsenals, without rail facilities, half a century ago.

The Rock Island Arsenal, in its present incompleted state, now supplies all the militia of most of the States and Territories drained by the great river and its tributaries, many of the fortresses that guard the coast-line of the Gulf of Mexico, and more than one-half of our Army, now scattered from the Mississippi River to the Rocky Mountains and beyond. When completed and fully equipped as a manufacturing arsenal, its capacity will equal the supplying of all the armies that may be organized in the Mississippi Valley in any war of the greatest magnitude.

Under the skillful management of its present commanding officer, Major Flagler, the erection of some of its extensive workshops, the completion of its water-power development, the construction of its long approaches and communications, and the arrangement and perfection of its numerous minor details, have been economically and admirably done.

POWDER-DEPOT AND POWDER-MILL.

An estimate has been submitted for the purchase of a site and the erection of magazines for the storage of gunpowder. The only powder-depot for the use of the Department is located at the Saint Louis Arsenal, Missouri, on the large Government reservation a few miles south of Saint Louis, but is too remote from the Atlantic seaboard to be of service for our wants in the eastern section of the country. Another depot is absolutely indispensable, to be located at some convenient point far away from our large cities and closely populated neighborhoods, but at a convenient distance from water transportation on the Atlantic coast. At present all our powder-supplies have to be stored in the small magazines at our arsenals in dangerous proximity to our cities, or in the forts of our harbors, where it is subject to the deteriorating influences of the sea-air. The annual saving to the Government in the preservation of powder at a well-established depot would, in a short time, repay the original expenditure.

The depot should also supply the necessary accommodation for the machinery and other appliances for the manufacture of powder for experiment, and to enable the Department to determine and fix the standard powder for Army uses. The want of a powder-mill for Army purposes has been long felt, and its erection is of prime necessity to the country. The Ordance Board of 1868, after a careful consideration of the subject, recommended the transfer to one of our arsenals of such machinery as might be available "for experimental purposes, in order to fix the best method of manufacturing gunpowder;" which recommendation was approved by the Secretary of War. Upon examination the machinery on hand was reported unsuitable for the purpose, and the approved recommendation of the board has remained unacted on to this day. The Board on Arsenals of 1874 (see report of Chief of Ordnance, 1874, page 163) earnestly recommended that Congress appropriate a sum for a powder-depot, "and the accommodation of suitable machinery and appliances for the manufacture of experimental powders." These views meet with the hearty concurrence of this Bureau, and, in support of the opinions and wishes so often expressed heretofore, I submit a letter from Col. T. T. S. Laidley, Ordnance Department, (marked "Appendix B,") for the consideration of the War Department and of Congress.

SMALL-ARMS.

The manufacture of Springfield rifles and carbines at the National Armory has been carried on during the past year with all the economy and success that the very small appropriation would admit of. The appropriation for the present fiscal year not being increased to any great amount by any other available funds under the control of this Department, the number of operatives at the armory has had to be largely reduced. Not more than 17,000 arms will be made under existing appropriations.

Up to date the entire Army has been supplied with new rifles and carbines, caliber .45, and we have now in store a reserve supply of these arms of about 26,000. At the end of the present fiscal year (June 30, 1876) our reserve supply may reach a total of 40,000 arms—of the new model and caliber—about enough in case of war to arm one *corps d'armée*.

It is not to be expected that in war our armies will be better satisfied with arms of obsolete patents and discarded models than in the early days of the rebellion they were with the offscourings of foreign markets.

Men who are to meet the enemy in battle have a right to demand of their country, in whose defense they are willing to imperil their lives, to be placed on an equality with the foe, and be armed with the best weapon that ingenuity and workmanship can produce. And in our country, where armies are to be improvised, made up on the instant by recruits from the anvil and the plow, the want of military discipline and training should be as much as possible compensated by the quality of the weapon the soldier is to use. Our arsenals should, therefore, be well stocked at all times with a large reserve supply of the best rifles and carbines, and Congress should, in the spirit of economy, appropriate liberally for their manufacture.

ARTESIAN WELL AT BENICIA ARSENAL.

The boring of the artesian well at the Benicia Arsenal has been continued during the past year, and a depth of 1,050 feet has been reached, the quantity of work accomplished being greater than in previous years. The commanding officer's report thereon is herewith transmitted, (marked "Appendix C.") With the appropriation now available for a continuation of the boring, it is hoped that during the current fiscal year a plentiful supply of water may be obtained.

THE INFANTRY SERVICE.

In May, 1874, the attention of the War Department was invited to the subject of a proper equipment for the infantry soldier, which had for some time been under the consideration of this Department, in the effort to perfect it in design and manufacture. Experimental equipments (a modification of the adopted English system) had been on trial by the troops in the field, and the data on file in this Bureau rendered it probable that, after full investigation, a judicious selection could be made. On my recommendation a board of infantry officers, of which Lieut. Col. W. R. Shafter, Twenty-fourth Infantry, was president, was appointed to meet on July 1, 1874, to consider and recommend the adoption of an equipment best suited to troops serving as infantry, and to determine on such material and supplies as may seem necessary for the efficient outfit of infantry troops in the field and garrison. After a session of five months, with all the facilities of the Watervliet Arsenal to assist the members in their investigations, the board made its report, which was approved, and is herewith submitted, (marked "Appendix D.") The equipment adopted is now being manufactured, and the troops will be supplied with it as rapidly as the resources under the control of the Department will permit.

INTERNATIONAL EXHIBITION, 1876.

The War Department having directed that the most complete exhibition of the resources of the various branches of the Army service should be made at the International Exhibition next year, to the extent of the appropriation allotted for that purpose, the war material and supplies prepared and controlled by the Ordnance Department it was thought would be of special interest, not only to our own citizens, but to visitors from abroad. That every care should be taken in furtherance of so important a matter, and that the display might be as creditable as possible in its selection and arrangement, it was deemed advisable to assign a capable officer to that duty. Lieut. Henry Metcalfe, Ordnance

Department, has been selected as peculiarly fitted to do full justice to the work, and it is confidently believed that, under his intelligent supervision and administration, this Department will make an exhibit that will be creditable to the country, and prove to be one of the most attractive features of the exhibition.

HEAVY ORDNANCE.

During the past year the proper armament for our sea coast defense has engaged the earnest attention of this Department, and a board of distinguished ordnance officers has been in permanent session, endeavoring to obtain all the data possible with the very straightened resources at the command of this Bureau. Its original report of December 14, 1874, was transmitted to Congress by the President of the United States in a special message of January 20, 1875. In that message the President urges "the absolute necessity for immediate provision by Congress for the procurement of heavy cannon," and adds that "the constant appeals for legislation on the 'armament of fortifications' ought no longer be disregarded, if Congress desires in peace to prepare the important material, without which future wars must inevitably lead to disaster." A small appropriation of $75,000 was all that was obtained from Congress in the interest of our sea-coast defense; but it is urgently recommended that the attention of Congress to this important subject be invoked, and that the appropriation of the money estimated for be strongly pressed upon its consideration.

Since the above-mentioned report on the 8-inch rifle was made, the board has continued its trials with that gun; and up to the present time it has been successfully fired 700 rounds with battering charges, and still remains "sound and serviceable," giving an endurance that fully justifies the recommendations of the board, and my approval, that our large number of smooth-bore guns ought to be converted into rifles, as it is entirely practicable to give the requisite strength and consequent endurance by the insertion of a wrought-iron tube. Additional proof of the correctness of this decision is found in the results obtained by the firing of the 9-inch rifle, (10-inch Rodman lined with wrought-iron tube,) which has thus far sustained 250 rounds, with battering charges of 40 to 45 pounds of hexagonal powder, and shot of 200 to 247 pounds weight, the gun remaining sound and in good condition.

The report of the board, December 14, 1874, with the additional reports received, including a detailed statement of the manner of making the coiled tubes and inserting them in the guns, are herewith submitted, (marked "Appendix E.") The experiments that have been conducted at Sandy Hook, and which constitute the burden of these reports, have been so successful and satisfactory in their results that they have awakened an interest among military men abroad, and to a surprising degree, when we realize our pigmy efforts at effecting results with insufficient means, and compare them with the extensive and elaborate trials, seemingly regardless of expense, that have been, and are being, prosecuted from year to year by almost every European nation.

We have the best cast-iron gun-metal known, and this plan of conversion enables us to utilize our own products. The wrought-iron tubes can probably be manufactured in this country also. And the combination of the two results in the production of a system of great strength and power. The success of the conversion of a 10-inch smooth-bore Rodman into an 8-inch rifle should be at once followed up by a trial of a 12-inch 35-ton gun made on a similar plan of conversion. We cannot stand with folded hands and permit other nations to get far in the van in a line of improvement in which the United States, not many years ago, knew no superior.

The successful manufacture and preliminary trial of the 81-ton gun in England is only another move in the great contest between guns and iron-clads; for the hurling of a rifle-shot of 1,250 pounds, with a velocity of 1,550 feet per second, cannot be considered the extreme limit to the development of artillery-power; and yet, for the want of the necessary appropriations, this country is forced to depend on a smooth-bore system and a few small rifles carrying shot of 180 and 250 pounds weight, which cannot possibly fulfill the important and ever-varying conditions of modern warfare. We are even now dependent for much of our information in these matters, so vital to the national defense, on the results of experiments abroad, at a time, too, when, had we the means, as we have the skill and ability, we could undoubtedly keep up successfully with the advances made by other nations. Rifle-guns of size, endurance, and power to enable us to meet on fair and equal terms a foreign foe must be provided while we have the time, and it is certainly not the part of wisdom to delay making such provision until the enemy invades our shores.

TESTING STEEL.

In order to secure the proper quality of material for the manufacture of the Woodbridge experimental gun, experiments on the mechanical properties of steel, produced from various materials and by different processes, with reference to its employment in the construction of cannon on that system, had to be undertaken. The report of Dr. W. E. Woodbridge of the tests made by him, under the orders of this Department, is herewith transmitted, (marked "Appendix F.")

INFRINGEMENT OF PATENTS.

I have the honor again to advert to the subject of patent-claims set up against this Department for alleged infringements in the productions at the National Armory and at the several arsenals of construction. The Chief of Ordnance, in his report for the year 1873, gave a succinct statement of the state of those claims at that time. The claims on the Springfield rifle date back to the order of the Secretary of War of July 28, 1866, for the conversion of 50,000 muzzle-loaders to breech-loading arms. The skill and ingenuity of the officers and workmen of the Ordnance Department, brought into active operation previous to that time and continued to the present, has resulted in the production of as perfect a single breech-loading arm as will find its place in modern war. Its mechanism, it is claimed, has touched upon and appropriated in part the best features of several distinct and separate patents, some of which were perfected and re-issued after the work of the Government had begun, and whose owners are now seeking compensation for the use.

The consideration of a patent-case involves a careful weighing of many matters of fact relating to novelty, priority, &c., as well as an appreciation of equivalents and dissimilarities in mechanical structures and contrivances, and the proper application of the principles of patent-law to facts thus found. Where a device stands boldly out as the original type of its class, and the many questions of a character to affect the validity of the patent are in such a case reasonably free from doubt, it is apprehended that it would require but ordinary patent-expert skill to settle with certainty the merits of any question of infringment that might be raised; but where *several* claimants profess to cover by their patents the same identical device or combination, a proper regard to the several interests involved renders the matter more difficult of determination. An impartial settlement requires, in most cases, the assistance of the highest degree of expert skill and the exercise of the highest order of legal talent in the specialty of patent-law. The law prescribes a judicial method of settlement where private parties only are concerned, but the means of deciding properly between contending patentees and determining the amount of damages sustained by them, or any of them, where the Army workshops are concerned, are not vested in any portion of this Department, nor, indeed, as respects cases wherein the United States are properly the defendants, are they known to be vested in any Department of the Government at the present time.

The methods adopted by some of the claimants of instituting suits in the United States circuit courts against officers of this Department for the alleged infringements is onerous to the officers themselves, and can only result, in the event of the success of the suits, in embarrassing such officers in their private means, whereas the Government is the sole beneficiary in the use of the things which are the subject-matters of litigation. A recent opinion of the Attorney-General has inferentially decided that the executive officers of the Government are not authorized to settle the judgments, for past use, rendered in such suits, without authority of Congress to do so. This opinion has been the guide of this Bureau since that time. The officers, therefore, against whom judgments might be rendered would be put to the harassing necessity of securing special legislation for their relief in respect to matters over which they have had little or no power or control.

The indemnity due to public officers who have acted in pursuance of competent authority in the performance of their public duty, or who have in good faith exercised the discretion vested in them by law, is secured to a certain class of Government officials by general legislation. Collectors and other officers of the revenue are thus secured by section 989, Revised Statutes. It is therein enacted, that when a recovery is had in any suit or proceeding against such officer for any act done by him, in the performance of his official duty, and the court certifies that there was probable cause for the act done by him, or that he acted under the direction of the Secretary of his Department, or other proper officer of the Government, no execution shall issue against him, but the amount so recovered shall, upon final judgment, be provided for and paid out of the proper appropriation from the Treasury. *Legislation similar to the foregoing, in favor of the officers of this Department* against whom recoveries may be had for infringement of patents in the productions of the armory and arsenals, would be a practicable method of relieving this Bureau of a present embarrassment.

It is believed, however, that, where several patents are alleged to cover a single complex device, each of these patents should be brought under the adjudication of a *common* tribunal, where the combined wisdom and experience necessary to the disposal of the whole number of cases could be brought to bear on each particular one in detail. If suits on such a device are brought by the several patentees in widely-separated jurisdictions, there is great liability of undue compensation being awarded to one patentee and inadequate remuneration to another, when the relative importance of the several patents is thereafter taken into account. It is, therefore, a question in the interest of the patentees themselves, as well as of public economy, whether some particular forum should not be named wherein claims of the character here referred to should be exclusively brought. The Court of Claims has denied its jurisdiction in cases of infringement of patent-rights by the Government, because such claims are held to sound in *tort*, and because the jurisdiction of the circuit courts is by law made exclusive in cases of patents. (See Pitcher's case, and Nock's case, 1 C. C. Repts., pp. 7 and 83.) Were it not, therefore, for these limitations upon the jurisdiction of the Court of Claims, this Department might readily refer all cases of alleged infringement for the decision of that tribunal under section 1063 of the Revised Statutes. Claimants before this Bureau for past use are now, however, without a remedy, except by personal actions against the officers of the Ordnance Department, (who have been and are acting under superior authority,) or by a direct application to Congress. As indicating the direction heretofore given by Congress to a complicated patent-case arising out of this Bureau, in order to secure for it the careful legal investigation which its importance demanded, attention is respectfully invited to the joint resolution of June 3, 1864, (13 S. L., p. 588,) referring the claim of William W. Hubbell to the Court of Claims. This claim was founded upon the use by the Government, to a very large extent, of devices covered by the patents of the claimant; and the court was directed to investigate and determine whether the claimant was the original inventor of the particular devices in question, and if he had a just and equitable right to compensation for the same; if so, what amount of compensation he was entitled to receive for the use of the inventions up to the time of adjudication, and for a full and entire transfer of his patents to the United States. This case, therefore, furnishes a precedent for the method of settling this class of cases; and, coupled with the advantages to accrue from the adjudication in a single tribunal of all patents where the United States is defendant, I would respectfully submit it to the wisdom of Congress *whether jurisdiction ought not to be given to the Court of Claims in all cases of the character here explained where the United States is defendant.* I earnestly recommend that some action may be taken at the coming session on this subject, which has engaged the attention of this Bureau for so long a time.

I have the honor to submit the following papers in addition to those heretofore mentioned:

Appendix G.—Statement of principal articles procured by purchase and fabrication at the arsenals during the year ended June 30, 1875.

Appendix H.—Statement of ordnance, ordnance-stores, &c., issued to the Regular Army and to posts during the year ended June 30, 1875.

Appendix I.—Apportionment of arms for the fiscal year ended June 30, 1875, under the law of 1808, for arming and equipping the militia, as amended by the seventh section of the act approved March 3, 1855, and regulations established in conformity therewith.

Appendix K.—Statement of ordnance, ordnance-stores, &c., distributed to the militia from July 1, 1874, to June 30, 1875, under the law of 1808, as amended by the seventh section of the act approved March 3, 1855.

Appendix L.—Statement of ordnance, ordnance-stores, &c., distributed to colleges from July 1, 1874, to June 30, 1875, under the joint resolution of May 4, 1870.

I have the honor to be, very respectfully, your obedient servant,

S. V. BENÉT,
Brigadier-General, Chief of Ordnance, U. S. A.

The Hon. the SECRETARY OF WAR.

APPENDIX A.

UNITED STATES ORDNANCE AGENCY,
New York City, June 1, 1875.

Proceedings of a board of ordnance officers convened in pursuance of the following order, to wit:

[Special Orders, No. 97.]

WAR DEPARTMENT, ADJUTANT GENERAL'S OFFICE,
Washington, May 22, 1875.

[EXTRACT.]

* * * * * * *

3. In pursuance of the act entitled "An act making appropriations for sundry civil expenses of the Government for the fiscal year ending June 30, 1876, and for other purposes," approved March 3, 1875, published in General Orders, No. 24, March 16, 1875, from this Office, a board of ordnance officers, to consist of Lieut. Col. Silas Crispin, Maj. T. J. Treadwell, Maj. T. G. Baylor, is appointed to meet in New York City, on the 1st day of June, 1875, or as soon thereafter as practicable, to visit and examine into the condition of the United States arsenals east of the Mississippi River, and to report how many of the same can be sold without interfering with the necessities of the military service, together with an estimate of the amount that can probably be realized from the sale of the same.

The visits will be made at such times as can be done without interfering with other duties.

The board will make their report to the Chief of Ordnance on or before October 1 next.

The junior member of the board will act as recorder.

The following is the paragraph of the act of Congress above referred to:

"And the Secretary of War is hereby directed to cause an examination to be made into the condition of the United States arsenals east of the Mississippi River, and report to the next Congress how many of the same can be sold without interfering with the necessities of the military service, together with an estimate of the amount that can probably be realized from the sale of each of the same whenever such sale shall be directed by Congress."

* * * * * * *

By order of the Secretary of War:

E. D. TOWNSEND,
Adjutant General.

Official:
L. H. PELOUZE,
Assistant Adjutant General.

The board met pursuant to the above order, all the members present.

The members of the board being all members of the board on "experimental guns," &c., and it having been represented to the board that there was important and urgent business to be considered by the latter board, it adjourned subject to the call of the president.

UNITED STATES ORDNANCE AGENCY,
New York City, June 12, 1875.

The board met in pursuance of the call of the president.

The board, after discussing the order in which it would visit the various arsenals east of the Mississippi River, adjourned to meet at Fort Monroe Arsenal, Va., under the order of the president.

FORT MONROE ARSENAL, VA.,
June 20, 1875.

The board met at this arsenal pursuant to adjournment.

A memorial from the citizens of Rome, Ga., to the honorable Secretary of War, setting forth its advantages as a site for an arsenal in the South, was received from the Chief of Ordnance, with an indorsement directing the board to proceed to Rome, Ga., and make a report on the subject.

The board, after inspecting the arsenal grounds and buildings at Fort Monroe, Va., adjourned to meet at Augusta, Ga.; June 23.

AUGUSTA, GA., *June* 23, 1875.

The board met at this place, pursuant to adjournment, and proceeded to inspect the grounds and buildings of the United States arsenal, situated some three miles from the city.

A letter was then addressed to the commanding officer, asking if there was any change in the value of lands and buildings, or in the rail and water communications at this arsenal since the report of that officer made to the board on arsenals in 1874.

The board then adjourned to meet at Rome, Ga., June 25, 1875.

ROME, GA., *June* 25, 1875.

The board met at this place pursuant to adjournment.

The board called upon the mayor, (Judge Spinlock,) who kindly offered his services to show the city and its environs; and under his guidance the board examined the manufacturing operations and rail and water communications of the city, in regard to its suitableness for a site for an arsenal.

The board then adjourned, subject to the call of the president; and the members rejoined their stations, under the order of the president.

UNITED STATES ORDNANCE AGENCY,
New York, August 18, 1875.

The board met pursuant to the call of the president. All the members present.

The board, after some discussion upon the routes to be taken and the order in which they would visit the arsenals to be inspected under their orders, determined first upon proceeding to Watervliet Arsenal, N. Y., and addressed a letter to the commanding officer, notifying him of this purpose.

At 3 p. m., the board adjourned to meet at Watervliet Arsenal, N. Y., on the 19th instant.

WATERVLIET ARSENAL,
West Troy, N. Y., August 19, 1875.

The board met at this arsenal pursuant to adjournment. Present, all the members.

The board, after inspecting the shops, buildings, &c., addressed a letter to the commanding officer.

At 4 p. m., the board adjourned to meet at Springfield Armory, Massachusetts, August 23, 1875.

SPRINGFIELD, MASS., *August* 23, 1875.

The board met pursuant to adjournment. All the members present.

A letter was addressed to the commanding officer of Springfield Armory, Massachusetts, notifying him of the contemplated visit of the board on the 24th instant.

The board then adjourned until 10 a. m., of the 24th instant.

SPRINGFIELD, MASS., *August* 24, 1875.

The board met pursuant to adjournment. All the members present.

The board proceeded to the armory, and after making the necessary inspections, adjourned to meet in Boston, Mass., August 25, 1875, for the purpose of inspecting Watertown Arsenal, Massachusetts, a letter having been addressed to the commanding officer of that arsenal advising him of this visit.

BOSTON, MASS., *August* 25, 1875.

The board met pursuant to adjournment. All the members present.

The board proceeded to Watertown Arsenal, and after making the necessary inspections and addressing a letter to the commanding officer, adjourned to meet in Augusta, Me., August 27, to examine into the condition of the arsenal at that place. A telegram was sent to the commanding officer, advising him of this visit.

AUGUSTA, ME., *August* 27, 1875.

The board met pursuant to adjournment. All the members present.

The board then visited the arsenal and made an inspection of the grounds and buildings, and addressed a letter to the commanding officer.

The board then adjourned, subject to the call of the president.

WASHINGTON, D. C., *September* 8, 1875.

The board met at this place, pursuant to the call of the president. All the members present.

The board proceeded to Washington Arsenal, and after the usual examination, addressed a letter to the commanding officer in regard to improvements and the value of lands and buildings.

The board then adjourned to meet in Baltimore, Md., September 10, for the purpose of visiting the Pikesville Arsenal.

BALTIMORE, MD., *September* 10, 1875.

The board met pursuant to adjournment. All the members present.

The Pikesville Arsenal was then visited and examined, after which the board adjourned to meet at Frankford Arsenal, Philadelphia, Pa., September 11, 1875.

FRANKFORD ARSENAL,
Philadelphia, Pa., September 11, 1875.

The board met pursuant to adjournment. All the members present.

The grounds and buildings at the arsenal were examined, and a letter addressed to the commanding officer on the subject of improvements and the value of the lands and buildings.

The board then adjourned to meet in New York City, September 14, 1875.

UNITED STATES ORDNANCE AGENCY,
New York, September 14, 1875.

The board met pursuant to adjournment. All the members present.

The board considered the question of the proper disposition of the different arsenals visited by them, and at 3 p. m., adjourned to meet at the United States Ordnance Agency, New York, September 15, at 10 a. m.

UNITED STATES ORDNANCE AGENCY,
New York, September 15, 1875.

The board met pursuant to adjournment. All the members present.

The board, after some further discussion, decided to continue its examination of the remainder of the arsenals east of the Mississippi River, and for this purpose, at 3 p. m., adjourned to meet at Pittsburgh, Pa., on the 16th instant, to inspect the Allegheny Arsenal.

ALLEGHENY ARSENAL,
Pittsburgh, Pa., September 16, 1875.

The board met pursuant to adjournment. All the members present.

The board proceeded to visit the arsenal, and after its examination a letter was addressed to the commanding officer.

The board then adjourned to meet at Indianapolis, Ind., September 18, to examine into the condition of the arsenal at that place.

INDIANAPOLIS, IND., *September* 18, 1875.

The board met pursuant to adjournment. All the members present.

The Indianapolis Arsenal was visited by the board and a letter addressed to the commanding officer.

The board then adjourned to meet at the United States Ordnance Agency, New York City, September 22, 1875.

UNITED STATES ORDNANCE AGENCY,
New York, September 22, 1875.

The board met pursuant to adjournment. All the members present.

Letters from the commanding officers of the following arsenals, viz: Augusta, Watervliet, Watertown, Kennebec, Washington, Frankford, Allegheny, and Indianapolis, in answer to letters of board on the subject of improvements and valuation of lands and buildings which had been received from time to time during the absence of the board, were read and filed.

A letter from Lieut. Col. S. Crispin, submitting the report of the board on arsenals of 1874, was received, read, and filed.

The report of that board is appended.

The condition of the New York Arsenal with regard to its facilities for storage and for supply of the Atlantic seaboard was then examined into.

The board then commenced the preparation of its report, and at 4 p. m., adjourned to meet at the United States Ordnance Agency, New York, at 10 a. m., September 23, 1875.

UNITED STATES ORDNANCE AGENCY,
New York, September 23, 1875.

The board met pursuant to adjournment. All the members present.

The board continued the preparation of its report, and at 4 p. m., adjourned to meet at the United States Ordnance Agency, September 24, at 10 a. m.

UNITED STATES ORDNANCE AGENCY,
New York, September 24, 1875.

The board met pursuant to adjournment. All the members present.

The board concluded its report, and, having no further business before it, adjourned *sine die.*

Opinions and recommendations of the board.

The board finds, from an examination of the records before it, that an exhaustive and comprehensive study of our present arsenal system, its facilities and its requirements, was made by the board on arsenals, convened under order of the Department, dated November 12, 1873, for the purpose of reporting "on the best method of concentrating the manufacturing operations of this Department east of the Mississippi River, either by the establishment of a grand arsenal on the Atlantic seaboard, or the enlargement of, and concentration of work in, one or more of our arsenals, discontinuing the remainder of the arsenals, or retaining one or more as mere places of deposit." That report embodies the following plan:

"PLAN 1.

"The Ordnance Department, for nearly the last thirty years, in the performance of the various duties intrusted to it by law, under the Secretary of War, in the manufacture and procurement of all ordnance and ordnance stores for armies called into the field at different times during this period, also in the providing of warlike stores for the prospective wants of future armies, the armaments and material for sea-coast defenses, the material for arming and equipping militia, and the performance of the important experimental duties intrusted to its care, has experienced during this period more or less serious embarrassment, not only from the inadequacy of existing facilities at the present arsenals of construction, but from their locations and limited resources, necessitating the conduction of the manufacturing operations at different points, widely separated, and being more or less objectionable on account of transportation, procurement of labor and material, and at the loss of the evident economy of a judicious concentration of ordnance manufactures.

"Our present arsenals of construction, located between the Mississippi River and Atlantic Ocean, are widely scattered from Maine to Georgia. This policy of location was necessary at the time of their establishment, when but few, if any, railroad means of transit existed in our country, and when it was important, from this cause, that equipment of troops should be made at or near the localities where raised.

"But at the present day, when our elaborate and perfected railroad and telegraph systems of communication have rendered the question of distance one of but secondary importance, we can now take advantage of these improvements, and subserve the true interests of economy, perfect our products, and attain the other manifest advantages of a policy of centralization by a concentration at one grand arsenal of the most important manufacturing operations of the Department.

"The great importance of carrying out this policy at a 'grand arsenal on the Atlantic seaboard' has been fully recognized and urged in the report of the Chief of Ordnance, of December 3, 1862, and repeatedly pressed upon the notice of the War Department, and the action of Congress earnestly recommended in the subsequent annual reports of this Office from 1869 to 1873.

"The first consideration in the location of an arsenal of construction, to effect these ends is, evidently, that it should occupy a comparatively central geographical position with respect to the Atlantic seaboard, and have at command the facilities of one of our great commercial centers.

"The pre-eminence of the city of New York, in its gigantic means for transit and for prompt distribution of all warlike stores to all points of the United States, its unsurpassed resources in labor and material, and its advantages in a geographical point of view over any city on our coast as a distributing-point, renders the location of an arsenal-site in its vicinity, if practicable, of the greatest importance; and accordingly the board has directed its examination, particularly to this section of the country.

"A consideration and examination of the surroundings of New York point conclusively to the immediate north of Newark, N. J., as the section of country possessing the best advantages, and as being most eligible and desirable for locating the proposed arsenal.

"The land here, bordering on the Passaic River, rises from the level of the river to a height of over 100 feet, and then gradually slopes eastward to the meadow-lands bordering on the Hackensack.

"The character of the ground gives it natural features of defense, and this, added to its location (see Map 1) with respect to important works of defense of New York Harbor, and its freedom from the possibility of naval attack, are considerations of the highest importance.

"The diverging main lines of railroad from Jersey City and Hoboken, at present eleven in number, bring this site in close and rapid communication with New York and the country at large, and the water-facilities of the Passaic and Hackensack are available for transportation of supplies to and from the harbor of the commercial metropolis of our country.

"A special site on this ground has been selected and surveyed (see report of Mr. H. N. Babcock, marked L") and is represented in detail on map marked 2.

"Its location with respect to New York City, Newark, and the surrounding country, also with respect to railroad and water means of transit with New York, is shown by the accompanying map, marked 3.

"It will be seen (Map 3) that this site is distant about * * from New York, and about three miles from the suburbs of Newark. It has a frontage on the Passaic of * * * * *, and extending eastward, as it does, from the Passaic River to the Hackensack meadows, it thus has access to both rivers.

"A short line of railroad * * * will connect the site with the railroad system of the country, and at a slight cost of construction, owing to the level character of the adjacent lands.

* * * * * * *

"A suitable proof-ground for ordnance adjoining the arsenal-site is shown on Map 3, and marked (P. G.) * * * It would constitute a valuable adjunct to the arsenal, and it is recommended that it be secured if the site for the latter be approved and purchased.

"The above-recommended purchases do not provide for storage-depots on the waters of New York Harbor, to be especially utilized in times of war. Our recent past experience in the rebellion has shown that such facilities can be readily extemporized when needed from buildings and wharfages already existing for ordinary commercial purposes in New York Harbor, and at a less cost than would be incurred in their permanent provision by the Government.

"It would appear, from the above considerations and facts, that a 'grand arsenal' of construction can be located, at a reasonable and moderate cost, on the Atlantic coast, and at the most desirable point for the concentration of ordnance manufactures.

"In view of this fact, there remains to be considered and determined the proper distribution of the duties of the Department, based upon the early establishment of this arsenal, and the proper disposition of such arsenals as its erection will render no longer needed for the services of the United States.

"The arsenals and armories now established east of the Mississippi River are as follows, to wit:

"Kenebec Arsenal, Augusta, Me.
"Watertown Arsenal, Watertown, Mass.
"Springfield Armory, Springfield, Mass.
"Watervliet Arsenal, West Troy, N. Y.
"New York Arsenal, Governor's Island, New York Harbor.
"Pikesville Arsenal, Pikesville, Md.
"Frankford Arsenal, Philadelphia, Pa.
"Washington Arsenal, Washington, D. C.
"Fort Monroe Arsenal, Old Point Comfort, Va.
"Augusta Arsenal, Augusta, Ga.
"Indianapolis Arsenal, Indianapolis, Ind.
"Columbus Arsenal, Columbus, Ohio.
"Allegheny Arsenal, Pittsburgh, Pa.
"Detroit Arsenal, Detroit, Mich.

"The principal manufacturing operations of the Department are now performed at the following arsenals, to wit: Watertown, engaged in the production of sea-coast carriages and projectiles for heavy guns; Springfield Armory, with the manufacture of small-arms; Watervliet, in the manufacture of leather-work; Frankford Arsenal, in small-arm ammunition, and Fort Monroe Arsenal, in sea-coast carriages and on experimental duties. The remaining arsenals in the above list are either engaged in small repairs or are simply storage-depots for the care and preservation, issue and receipt of ordnance and ordnance-stores. It is believed that, except small-arms and small-arm ammunition, the more important ordnance and ordnance-stores, more especially those for field and siege artillery, and those to be provided for the use of our sea-coast defenses, such as cannon, heavy sea-coast carriages, projectiles, and ammunition, and other stores and appliances for their service and maneuver, also harness and the more elaborate articles of leather-work, should all be made at the grand arsenal of construction.

"The manufacture of our small-arms and small-arm ammunition for our present armies and militia, and for our reserve-supply, is one of the greatest importance, and as the Springfield Armory is a model one of the world in the perfection of its fabrications, and the extent and completeness of its arrangements and facilities for the production of this class of warlike stores, the board regards the retention of this establishment as a foregone conclusion, in its proposed plan for concentration, for the fabrication of its present specialty, and such other work as its facilities may accommodate. Recognizing also the almost imperative necessity, in order to secure perfection in production in the fabrication of small-arms and small-arm ammunition, that they should be produced side by side, the board is of the opinion that arrangements should be made for the transfer of the present manufacturing operations of small-arm cartridges at Frankford Arsenal to the Sprinfield Armory as early as it can be accomplished with economy and with a due regard to other important public interests. The more simple leather-work fabrications of infantry and cavalry accouterments, and perhaps some other kinds, all demanded in quantity, and requiring little but no special appliances for their manufacture, can, it is thought, be economically and judiciously made at one of our present arsenals. The board recommends the retention of the Frankford Arsenal for this purpose. Its geographical position and its facilities of shops and store-houses and for material and labor of the kind required, its means of transit, and its close and quick connection with the proposed grand arsenal at Newark, N. J., point conclusively to its retention for the purpose suggested, and as part of the proposed plan for concentration.

"It will be seen that the design contemplated by the board is to concentrate all the principal manufacturing operations of the Department at the proposed grand arsenal, the Springfield Armory, and at Frankford Arsenal.

"It remains now to designate those arsenals which it is proposed shall be retained to meet the wants of the country as arsenals for storage and repair, and those to be used simply as depots for the care, preservation, receipt, and issue of warlike stores.

"A careful and mature consideration of the question leads the board to recommend the retention of the following arsenals, to wit: Augusta and Fort Monroe as arsenals of storage and repair, and Kennebec, New York, and Indianapolis arsenals as depots for storage and issue. This will leave to be sold the Watertown, Watervliet, Pikesville, Washington, Allegheny, Columbus, and Detroit arsenals.

"The reasons for the retention of the above arsenals, as recommended by the board, are as follows, to wit:

"*Augusta Arsenal.*—This is the only arsenal left in the entire South, east of the Mississippi, and the nearest constructing arsenal to it in the proposed plan will be nearly eight hundred miles distant. Its retention and improvement and sufficient enlargement to render it adequate to supply the needs of the Department in the South, in the opinion of the board, is a matter of wisdom, and in fact a necessity. The proposed improvements and enlargement (see memorandum letter of board addressed to Captain Hill, March 7, 1874, official copy of which was sent to that officer March 16, 1874, and the report of that officer dated March 16, 1874) can be secured at a moderate cost. Its present workshops and buildings are in excellent condition, are sufficiently large in plan to be utilized almost without cost in the remodeling of the arsenal as one for storage and repair. The location, inland, is one of the best in the South, both geographically and in its rail and water facilities, for the reception and distribution of supplies for the South. These and its other advantages for the purposes required, (see Captain Hill's report,) and its general healthfulness, further confirm the board in its opinion as to the propriety and necessity of retention of the Augusta Arsenal. Its general plan and its location with respect to Augusta City is given in the accompanying map marked 4.

"*Fort Monroe Arsenal, Virginia.*—This arsenal is located on a Government reservation, and its connection with Fort Monroe renders its sale impossible. It is well provided with shops and machinery, and is admirably situated geographically on the waters of Hampton Roads for fitting out expeditions, as was shown in the late war.

"The arsenal as it now exists, however, is considerably scattered over the Government reservation, and, as a matter of economy and efficiency, it is recommended by the board that all the arsenal property inside the fort, consisting of quarters, barracks, and office, be turned over to the garrison of Fort Monroe. The store-houses and other temporary buildings should be torn down and the materials applied, as far as practicable, to the erection of suitable structures rendered necessary by this action, outside the fort in the vicinity of its shops. The necessary buildings required to be erected by this plan would cost but little additional to the value of the material obtained by the removal of the store-houses and buildings inside the fort. The buildings inside the fort should not be abandoned or turned over until their places are supplied by suitable structures contemplated to be erected outside the fort.

"*Kennebec Arsenal.*—This arsenal is situated on our northeastern frontier, bordering on Canada, is well located, has the requisite facilities, and is deemed necessary for retention to supply the present and prospective wants of that section of our country.

"*New York Arsenal.*—This arsenal, located on the glacis-slope of Fort Columbus, Governor's Island, is not available for sale. Whilst incapable of and having no manufacturing facilities, yet it has comparatively extensive storage capacity and wharfage, and superior facilities, from its location in New York Harbor, for the distribution of supplies, and will thus form a valuable adjunct for storage in connection with the proposed grand arsenal.

"*Indianapolis Arsenal.*—The construction of a large arsenal on the Atlantic coast and the disestablishment of the interior ones—Allegheny and Columbus—will leave, it is believed, too great an area of country between the Atlantic coast and the Rock Island arsenal (the proposed arsenal and armory of the valley of the Mississippi) unprovided with an ordnance-depot, and hence the board recommend the retention of the Indianapolis arsenal as one for storage and issue to meet the wants of the northern-lake frontier and the central portion of our country lying to the immediate west of the Atlantic States. Indianapolis is a great railroad center; its other facilities are prominent, and the present arsenal at this point has, in its substantial and capacious store-houses and other advantages, all that is needed for the purpose required.

"In order to inaugurate this general plan for concentration the board recommend that Congress be asked to make the necessary appropriations for the immediate purchase of the site for the grand arsenal proposed, and for the erection of suitable buildings immediately required thereon, and to enact a law authorizing the sale of the arsenals above designated.

"The arsenals that can be soon prepared for disposition are Washington, Allegheny, Columbus, Detroit, and Pikesville. The following arsenals should be disposed of at such times as the stores now manufactured at them can be provided for at the grand arsenal, viz: Watertown Arsenal, Massachusetts, and Watervliet Arsenal, New York. It is apparent that no sales should be made until the Department is fully prepared elsewhere to replace the facilities lost by the disposal of any of our arsenals.

"It is evident that any judicious plan for the disposition of even those arsenals most available at present for sale, under the above-proposed arrangement of the ordnance facilities for the United States, would require two or three years for consummation, and hence the necessity of appropriations by Congress to secure the site for the contemplated 'grand arsenal,' and its preparation for buildings; the erection of some, and the making of improvements required at its initiation, cannot but be apparent.

"It should be provided by law that the net proceeds of all sales of our arsenals should be used in building up the 'grand arsenal.' The present estimated cost of the arsenal-site and adjacent proof-ground is $262,275.

"To purchase this site and to provide for improvements and buildings which should and can be provided during the first year, it is recommended that Congress be asked at its next session for an appropriation adequate to secure the site and proof-ground, and an additional sum not exceeding $500,000 for such improvements and structures as the Department may deem best and most expedient to at first provide.

"The accompanying statement, prepared from the reports of the commanding officers, appended, marked AA, shows an estimated return from the sale of those arsenals which can be most readily prepared for disposition at present, (if the proposed plan is adopted,) in the aggregate of $2,109,590.56, and that the proceeds of the two remaining ones, Watertown and Watervliet, whose disposition must be at least delayed until they are fully superseded by the proposed new arsenal, will be $1,414,237. Valuable machinery now on hand at the arsenals recommended to be sold and dismantled can be utilized at the 'grand arsenal.' The grand aggregate resulting from the contemplated sales will be $3,526,827.56. This amount will undoubtedly go far toward, if not be entirely adequate for, the full accomplishment of the contemplated concentration of our ordnance manufactures and facilities, and at a point whose superior local, geographical, and other advantages seem to demand centralization; and when we consider the undoubted improvements to be attained, the ease with which they can be secured, and the prospectively small outlay required, it is believed that sound judgment and a wise economy will point to the importance of an early accomplishment of this proposed distribution of the duties of the Ordnance Department of the United States."

No material changes in values of grounds, buildings, or other appointments of our arsenals have occurred since the date of the above-quoted report, and the status remains the same, save that the Columbus and Detroit arsenals have passed from the control of the Department, the former having been turned over to the recruiting service, and the latter to the Department of the Interior. This leaves the arsenals and armories east of the Mississippi as follows:

Kennebec Arsenal, Augusta, Me.
Watertown Arsenal, Watertown, Mass.
Springfield Armory, Springfield, Mass.
Watervliet Arsenal, West Troy, N. Y.
New York Arsenal, Governor's Island, N. Y. H.
Pikesville Arsenal, Pikesville, Md.
Frankford Arsenal, Philadelphia, Pa.
Washington Arsenal, Washington, D. C.
Fort Monroe Arsenal, Old Point Comfort, Va.
Augusta Arsenal, Augusta, Ga.
Indianapolis Arsenal, Indianapolis, Ind.
Allegheny Arsenal, Pittsburgh, Pa.

The present absolute needs of the service demand, in the judgment of the board, all the manufacturing facilities of the Springfield armory, Frankford, Watervliet, Watertown, and Fort Monroe arsenals, for the production of warlike stores, and the remaining ones, Kennebec, New York, Washington, Augusta, Indianapolis, and Allegheny, are required for their present uses, to wit, care and preservation, issue and receipt, and repair of ordnance and ordnance stores.

It will be seen that but one arsenal (Pikesville) remains as not necessary for the wants of the Department. Its estimated value is $46,635. It should be sold.

The board, from the above, therefore deems the retention of all our arsenals east of the Mississippi, except Pikesville, as essential for the necessities and proper service of the Ordnance Department, and strongly recommends that no other arsenal be disposed of by sale or otherwise, unless it becomes feasible, by congressional legislation, to carry out the plan of concentration in the manner proposed by plan No. 1, of the report of the Board on Arsenals of 1874. In concluding this report, the board, concurring to the fullest extent in plan No. 1 of the report of the Board on Arsenals of 1874, would earnestly urge on the Department the wisdom and economy of the concentration of ordnance manufactures and other facilities as proposed by that plan, and recommends its favorable indorsement by the proper authorities for congressional action.

Opinions and recommendations of the board.

Rome, Ga., as a proposed site for a United States arsenal for the South:

The geographical position of the mountainous region of Northwestern Georgia, the general healthfulness of this part of the South, and its great natural advantages in mineral wealth and agricultural resources, render this section of our country prominent for the location of sites for manufacturing purposes, especially those devoted to such fabrications as are needed for ordnance uses.

Rome, well located at the confluence of Oostanaula and Etowah, forming the Coosa branch of the Alabama, has a well-developed railroad system connecting it with the great trunk roads of the United States, and by the contemplated improvements of its water-courses, can be connected by this mode of transit with the Gulf of Mexico. The resources of the immediate surrounding country in iron-ores, and the means of its reduction into charcoal pig, its agricultural and manufacturing advantages, its availability in sites for workshops and other essential features for an industrial establishment, are additional elements in its favor.

While, however, acknowledging its merits in the above regards, yet its geographical position and rail and water communications (prime and essential features in location) are, in the opinion of the board, inferior to those of the Augusta Arsenal, Ga. The latter being already located and provided with suitable buildings, has all the prime requisites for a southern arsenal for storage and repairs, and the board cannot, therefore, favorably recommend at this present juncture its abandonment and the provision of a new arsenal at Rome, Ga.

S. CRISPIN,
Bvt. Col. U. S. A., Lieut. Col. Ordnance, President of the Board.
T. J. TREADWELL,
Major of Ordnance.
T. G. BAYLOR,
Major of Ordnance, Recorder.

Opinions and recommendations of the board of officers convened by orders of the Chief of Ordnance, dated November 12, 1873.

* * * * * * *

"On the best method of concentrating the manufacturing operations of this Department east of the Mississippi River, either by the establishment of a grand arsenal on the Atlantic seaboard or the enlargement of, and concentration of work in, one or more of our arsenals, discontinuing the remainder of the arsenals, or retaining one or more as mere places of deposit."

PLAN 1.

"The Ordnance Department, for nearly the last thirty years, in the performance of the various duties intrusted to it by law, under the Secretary of War in the manufacture and procurement of all ordnance and ordnance stores for armies called into the field at different times during this period, also in the providing of warlike stores for the prospective wants of future armies, the armaments and material for sea-coast defenses, the material for arming and equipping the militia, and the performance of the important experimental duties intrusted to its care, has experienced during this period more or less serious embarrassment, not only from the inadequacy of existing facilities at the present arsenals of construction, but from their locations and limited resources, necessitating the conduction of the manufacturing operations at different points, widely separated, and being more or less objectionable on account of transportation, procurement of labor and material, and at the loss of the evident economy of a judicious concentration of ordnance manufactures.

"Our present arsenals of construction, located between the Mississippi River and Atlantic Ocean, are widely scattered from Maine to Georgia. This policy of location was necessary at the time of their establishment when but few, if any, railroad means of transit existed in our country, and when it was important, from this cause, that equipment of troops should be made at or near the localities where raised.

"But at the present day, when our elaborate and perfected railroad and telegraph systems of communication have rendered the question of distance one of but secondary importance, we can now take advantage of these improvements, and subserve the true interests of economy, perfect our products, and attain the other manifest advantages of a policy of centralization by a concentration at one grand arsenal of the most important manufacturing operations in the Department.

"The great importance of carrying out this policy at a 'grand arsenal on the Atlantic seaboard' has been fully recognized and urged in the report of the Chief of Ordnance of December 3, 1862, and repeatedly pressed upon the notice of the War Department, and the action of Congress earnestly recommended in the subsequent annual reports of this Office from 1869 to 1873.

"The first consideration in the location of an arsenal of construction, to effect these ends, is, evidently, that it should occupy a comparatively central geographical position with respect to the Atlantic seaboard, and have at command the facilities of one of our great commercial centers.

"The pre-eminence of the city of New York, in its gigantic means for transit and for prompt distribution of all warlike stores to all points of the United States, its unsurpassed resources in labor and material, and its advantages in a geographical point of view over any city on our coast as a distributing-point, renders the location of an arsenal-site in its vicinity, if practicable, of the greatest importance; and, accordingly, the board has directed its examination particularly to this section of the country.

"A consideration and examination of the surroundings of New York point conclusively to the immediate north of Newark, N. J., as the section of country possessing the best advantages, and as being most eligible and desirable for locating the proposed arsenal.

"The land here, bordering on the Passaic River, rises from the level of the river to a height of over 100 feet, and then gradually slopes eastward to the meadow-lands bordering on the Hackensack.

"The character of the ground gives it natural features of defense, and this, added to its location (see Map 1) with respect to important works of defense of New York Harbor, and its freedom from the possibility of naval attack, are considerations of the highest importance.

"The diverging main lines of railroad from Jersey City and Hoboken, at present eleven in number, bring this site in close and rapid communication with New York and the country at large, and the water-facilities of the Passaic and Hackensack are available for transportation of supplies to and from the harbor of the commercial metropolis of our country.

"A special site on this ground has been selected and surveyed (see report of Mr. H. N. Babcock marked L") and is represented in detail on map marked 2.

"Its location with respect to New York City, Newark, and the surrounding country, also with respect to railroad and water means of transit with New York, is shown by the accompanying map, marked 3.

"It will be seen (Map 3) that this site is distant about * * * from New York, and about three miles from the suburbs of Newark. It has a frontage on the Passaic of * * * * *, and extending eastward, as it does, from the Passaic River to the Hackensack meadows, it thus has access to both rivers.

"A short line of railroad * * * will connect the site with the railroad system of the country, and at a slight cost of construction, owing to the level character of the adjacent lands.

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"A suitable proof-ground for ordnance adjoining the arsenal-site is shown on Map 3, and marked (PG.) * * * It would constitute a valuable adjunct to the arsenal, and it is recommended that it be secured, if the site for the latter be approved and purchased.

"The above-recommended purchases do not provide for storage-depots on the waters of New York Harbor, to be specially utilized in times of war. Our recent past experience in the rebellion has shown that such facilities can be readily extemporized when needed from buildings and wharfages already existing for ordinary commercial purposes in New York Harbor, and at a less cost than would be incurred in their permanent provision by the Government.

"It would appear from the above considerations and facts, that a 'grand arsenal' of construction can be located, at a reasonable and moderate cost, on the Atlantic coast, and at the most desirable point for the concentration of ordnance manufactures.

"In view of this fact, there remains to be considered and determined the proper distribution of the duties of the Department, based upon the early establishment of this arsenal, and the proper disposition of such arsenals as its erection will render no longer needed for the services of the United States.

"The arsenals and armories now established east of the Mississippi River are as follows, to wit:

Kennebec Arsenal, Augusta, Me.
Watertown Arsenal, Watertown, Mass.
Springfield Armory, Springfield, Mass.
Watervliet Arsenal, West Troy, N. Y.
New York Arsenal, Governor's Island, New York Harbor.
Pikesville Arsenal, Pikesville, Md.
Frankford Arsenal, Philadelphia, Pa.
Washington Arsenal, Washington, D. C.
Fort Monroe Arsenal, Old Point Comfort, Va.
Augusta Arsenal, Augusta, Ga.
Indianapolis Arsenal, Indianapolis, Ind.
Columbus Arsenal, Columbus, O.
Allegheny Arsenal, Pittsburgh, Pa.
Detroit Arsenal, Detroit, Mich.

"The principal manufacturing operations of the Department are now performed at the following arsenals, to wit: Watertown, engaged in the production of sea-coast carriages and projectiles for heavy guns; Springfield Armory, with the manufacture of small-arms; Watervliet, in the manufacture of leather-work; Frankford Arsenal, in small-arm ammunition, and Fort Monroe Arsenal, in sea-coast carriages and on experimental duties. The remaining arsenals in the above list are either engaged in small repairs or are simply storage-depots for the care and preservation, issue and receipt, of ordnance and ordnance stores. It is believed that, except small-arms and small-arm ammunition, the more important ordnance and ordnance stores, more especially those for field and siege artillery and those to be provided for the use of our sea-coast defenses, such as cannon, heavy sea-coast carriages, projectiles, and ammunition, and other stores and appliances for their service and maneuver, also harness and the more elaborate articles of leather-work, should all be made at the grand arsenal of construction.

"The manufacture of our small-arms and small-arm ammunition for our present armies and militia, and for our reserve supply, is one of the greatest importance; and as the Springfield Armory is a model one of the world in the perfection of its fabrications, and the extent and completeness of its arrangements and facilities for the production of this class of warlike stores, the board regards the retention of this establishment as a foregone conclusion, in its proposed plan for concentration, for the fabrication of its present specialty, and such other work as its facilities may accommodate. Recognizing also the almost imperative necessity, in order to secure perfection in production in the fabrication of small-arms and small-arm ammunition, that they should be produced side by side, the board is of the opinion that arrangements should be made for the transfer of the present manufacturing operations of small-arm cartridges at Frankford Arsenal to the Springfield Armory as early as it can be accomplished with economy and with a due regard to other important public interests. The more simple leather-work fabrications of infantry and cavalry accouterments, and perhaps some other kinds, all demanded in quantity, and requiring little but no special appliances for their manufacture, can, it is thought, be economically and judiciously made at one of our present arsenals. The board recommends the retention of the Frankford Arsenal for this purpose. Its geographical position and its facilities of shops and store-houses and for material and labor of the kind required, its means of transit and its close and quick connection with the proposed grand arsenal at Newark, N. J., point conclusively to its retention for the purpose suggested, and as part of the proposed plan for concentration.

"It will be seen that the design contemplated by the board is to concentrate all the principal manufacturing operations of the Department at the proposed grand arsenal, the Springfield Armory, and at Frankford Arsenal.

"It remains now to designate those arsenals which it is proposed shall be retained to meet the wants of the country as arsenals for storage and repair, and those to be used simply as depots for the care, preservation, receipt, and issue of warlike stores.

"A careful and mature consideration of the question leads the board to recommend the retention of the following arsenals, to wit: Augusta and Fort Monroe as arsenals of storage and repair, and Kennebec, New York, and Indianapolis arsenals as depots for storage and issue. This will leave to be sold the Watertown, Watervliet, Pikesville, Washington, Allegheny, Columbus, and Detroit arsenals.

"The reasons for the retention of the above arsenals, as recommended by the board, are as follows, to wit:

"*Augusta Arsenal.*—This is the only arsenal left in the entire South, east of the Mississippi, and the nearest constructing arsenal to it in the proposed plan will be nearly eight hundred miles distant. Its retention and improvement, and sufficient enlargement to render it adequate to supply the needs of the Department in the South, in the opinion of the board is a matter of wisdom, and in fact a necessity. The proposed improvements and enlargement (see memorandum letter of board addressed to Captain Hill, March 7, 1874, official copy of which was sent to that officer March 16, 1874, and the report of that officer, dated March 16, 1874,) can be secured at a moderate cost. Its present workshops and buildings are in excellent condition, are sufficiently large in plan to be utilized almost without cost in the remodeling of the arsenal as one for storage and repair. The location, inland, is one of the best in the South, both geographically and in its rail and water facilities, for the reception and distribution of supplies for the South. These and its other advantages for the purposes required, (see Captain Hill's report,) and its general healthfulness, further confirm the board in its opinion as to the propriety and necessity of retention of the Augusta Arsenal. Its general plan and its location with respect to Augusta City is given in the accompanying map, marked 4.

"*Fort Monroe Arsenal, Virginia.*—This arsenal is located on a Government reservation, and its connection with Fort Monroe renders its sale impossible. It is well provided with shops and machinery, and is admirably situated geographically on the waters of Hampton Roads for fitting out expeditions, as was shown in the late war.

"The arsenal as it now exists, however, is considerably scattered over the Government reservation, and as a matter of economy and efficiency it is recommended by the board that all the arsenal property inside the fort, consisting of quarters, barracks, and office, be turned over to the garrison of Fort Monroe. The store-houses and other temporary buildings should be torn down and the materials applied, as far as practicable, to the erection of suitable structures rendered necessary by this action, outside the fort in the vicinity of its shops. The necessary buildings required to be erected by this plan would cost but little additional to the value of the material obtained by the removal of the store-houses and buildings inside the fort. The buildings inside the fort should not be abandoned or turned over until their places are supplied by suitable structures contemplated to be erected outside the fort.

"*Kennebec Arsenal.*—This arsenal is situated on our northeastern frontier, bordering on Canada, is well located, has the requisite facilities, and is deemed necessary for retention to supply the present and prospective wants of that section of our country.

"*New York Arsenal.*—This arsenal, located on the glacis-slope of Fort Columbus, Governor's Island, is not available for sale. Whilst incapable of and having no manufacturing facilities, yet it has comparatively extensive storage capacity and wharfage, and superior facilities, from its location in New York Harbor, for the distribution of supplies, and will thus form a valuable adjunct for storage in connection with the proposed grand arsenal.

"*Indianapolis Arsenal.*—The construction of a large arsenal on the Atlantic coast and the disestablishment of the interior ones—Allegheny and Columbus—will leave, it is believed, too great an area of country between the Atlantic coast and the Rock Island Arsenal (the proposed arsenal and armory of the valley of the Mississippi) unprovided with an ordnance-depot, and hence the board recommend the retention of the Indianapolis Arsenal as one for storage and issue to meet the wants of the northern-lake frontier and the central portion of our country lying to the immediate west of the Atlantic States. Indianapolis is a great railroad center; its other facilities are prominent, and the present arsenal at this point has in its substantial and capacious store-houses and other advantages all that is needed for the purpose required.

"In order to inaugurate this general plan for concentration the board recommend that Congress be asked to make the necessary appropriations for the immediate purchase of the site for the grand arsenal proposed, and for the erection of suitable buildings immediately required thereon, and to enact a law authorizing the sale of the arsenals above designated.

"The arsenals that can be soon prepared for disposition are Washington, Allegheny, Columbus, Detroit, and Pikesville. The following arsenals should be disposed of at such times as the stores now manufactured at them can be provided for at the grand arsenal, viz: Watertown Arsenal, Massachusetts, and Watervliet Arsenal, New York. It is apparent that no sales should be made until the Department is fully prepared elsewhere to replace the facilities lost by the disposal of any of our arsenals.

"It is evident that any judicious plan for the disposition of even those arsenals most available at present for sale, under the above-proposed arrangement of the ordnance facilities for the United States, would require two or three years for consummation, and hence the necessity of appropriations by Congress to secure the site for the contemplated 'grand arsenal,' and its preparation for buildings; the erection of some, and the making of improvements required at its initiation, cannot but be apparent.

"It should be provided by law that the net proceeds of all sales of our arsenals should be used in building up the 'grand arsenal.' The present estimated cost of the arsenal-site and adjacent proof-ground is $262,275.

"To purchase this site and to provide for improvements and buildings which should and can be provided during the first year, it is recommended that Congress be asked at its next session for an appropriation adequate to secure the site and proof-ground, and an additional sum, not exceeding $500,000, for such improvements and structures as the Department may deem best and most expedient to at first provide.

"The accompanying statement, prepared from the reports of the commanding officers, appended, marked AA, shows an estimated return from the sale of those arsenals which can be most readily prepared for disposition at present, (if the proposed plan is adopted,) in the aggregate of $2,109,590.56, and that the proceeds of the two remaining ones, Watertown and Watervliet, whose disposition must be at least delayed until they are fully superseded by the proposed new arsenal, will be $1,414,237. Valuable machinery now on hand at the arsenals recommended to be sold and dismantled can be utilized at the 'grand arsenal.' The grand aggregate resulting from the contemplated sales will be $3,526,827.56. This amount will undoubtedly go far toward, if not be entirely adequate for, the full accomplishment of the contemplated concentration of our ordnance manufactures and facilities, and at a point whose superior local, geographical, and other advantages seem to demand centralization; and when we consider the undoubted improvements to be attained, the ease with which they can be secured, and the prospectively small outlay required, it is believed that sound judgment and a wise economy will point to the importance of an early accomplishment of this proposed distribution of the duties of the Ordnance Department of the United States."

PLAN 2.

"While the board is unanimous in the opinion that the foregoing plan will in the best and most satisfactory manner economize and perfect the manufactures of the Department, and otherwise provide for its wants east of the Mississippi, yet it feels called upon, under the orders convening it, to submit another arrangement for concentration, based upon the extension of the grounds and the enlargement of the manufacturing and storage facilities of one of our large arsenals of construction, in lieu of the establishment of a new one.

"The board finds this a difficult, if not impossible, problem to satisfactorily solve, owing to the want of a decided pre-eminence in the important essentials requisite at any one of our present arsenals of construction. The one best adapted for this purpose and possessing greater advantages than any other, from its central geographical position with respect to the Atlantic coast, (see map marked No. 23,) easy and ready procurement of labor and material, and from its facilities for storage, transportation, and distribution of its products, is the Frankford Arsenal. Its enlargement is practicable, as the adjoining farms (see appended map, marked 5, and report of the commanding officer) can be purchased.

* * * * * * *

"The water-frontage of Frankford Arsenal on the Delaware can be made available for transportation, and the grounds can be readily connected by rail with the great railroad system of our country.

"Its geographical position is by no means as acceptable as the proposed site near New York City, and its extension would not in the highest degree provide for our wants; but yet it is the only establishment for the purpose that the board can in its judgment point to as entitled to consideration, with the view to enlargement and modification, to supply the place of a new grand arsenal of construction.

"In the event, however, of its contemplated enlargement, the board recommends that the Springfield Armory, in addition to its present uses and the manufacture of small-arm ammunition, have also transferred to it the manufacture of that class of leather-work contemplated in the first plan to be fabricated at Frankford arsenal.

"This arrangement, as no other changes in the first plan proposed by the board are deemed advantageous, would leave, after the disposition of the arsenals heretofore recommended to be sold, the ordnance duties of the country to be performed at the following arsenals and armories, viz:

First. Frankford Arsenal, Springfield Armory—arsenal and armory of construction.

Second. Fort Monroe Arsenal, Augusta Arsenal—arsenals for storage, issue, and repair.

Third. Kennebec Arsenal, New York Arsenal, and Indianapolis Arsenal—arsenals for storage and issue.

"In concluding this part of the report, the board feels called upon to state that this second plan, in its judgment, offers no considerable advantages even on the score of economy, and, therefore, it feels constrained not to recommend its adoption unless it is impracticable to carry out the first plan or its equivalent.

"The accompanying maps, marked from 4 to 17, show the extent of the grounds and location of the buildings at our present arsenals east of the Mississippi. The geographical positions of the arsenals and their rail and water communications are shown on map No. 24.

POWDER-DEPOT SITES.

"The essential requisites for a powder-depot site are fully set forth in the instructions of the Chief of Ordnance to the board convened at New York City, dated October 6, 1866, to wit:

'In selecting sites for these two depots, the following considerations must be observed:

'1st. The depots should be in a region of country which does not admit of being densely populated, so that the destruction of life and property by accidental explosions would be as small as possible.

'2d. They should be of sufficient extent to contain in suitable positions magazines to store not less than 10,000 tons of powder for the depot near New York, and not less than 6,000 tons for the other depot

'3d. They should be near to a principal railroad, that they may be readily connected with it by a railroad belonging to the Government, and at a point where transportation can be had with facility at all seasons to all points on the seaboard, to the interior, and to the lake frontier.'

"The board, although deeming it of the first importance that the powder-depot should be established near the contemplated grand arsenal of construction, yet in its surveys due attention was paid to important local particulars.

"The vicinity of New York, on the line of the Erie Railroad, it was known from the surveys of the board of 1866, could not only furnish sites in every way desirable for the proposed depot, but the best attainable in the country.

"The board made not only the surveys made by the board of 1866, but also additional ones.

"The special particulars of the sites selected to choose from are given in the accompanying maps marked from — to —, and their relative positions to the proposed grand arsenal are given in the accompanying map marked —.

"Regarding this subject, the board (concurring in the opinion and facts therein set forth) quote the following from the report of the board of 1866:

'The location of a site for the depot to be established in the vicinity of New York City was deemed to be the first subject for consideration, and preliminary examinations of the most approved local maps—containing in minute detail the topographical features of the surrounding country and the different converging lines of railroad to New York—were made and detailed inquiries instituted among parties possessing accurate and special knowledge of the characters of *special localities*.

'A combination of immediate water and railroad facilities for transportation was regarded as a desideratum, but this condition, it was found, could not be fulfilled near New York without sacrificing the more important requirements of a site as set forth in the instructions of the Department.

'The results of the preliminary inquiries and examinations of the board pointed decidedly and clearly to the valley of the Ramapo River, between the town of Sufferns, N. Y., and Turner's Station, N. Y., along the line of the Erie Railroad, and distant from New York from thirty-two to fifty miles, as the only general locality which had all the prime requisites, and would in all probability furnish the desired site. (See map No. 18.) A *detailed examination* on the part of the board of this tract of country—extending from Sufferns to Turner's—was made. The general topographical features of this part of the Ramapo Valley were found to be hills on either side varying from 100 to 500 feet in height (the terminating slopes of the Taconic range) skirting the narrow bottom-lands on which the Erie Railroad is located, and here and there broken by narrow ravines diverging at different angles from the valley, and at intervals interrupted by broader ones, on some of which are located the small villages of Ramapo and Sloatsburgh and the hamlet of Southfields. In rear of these heights the country is broken by narrow ravines parallel to the valley and walled in by the opposite hills.

'These superior natural features for our purposes, with the absence of inhabitants and of arable grounds for cultivation and support of a dense population, determined the question as far as general location was concerned, and the special examinations made led to the selection of a tract which, it is believed, will afford an excellent site, and one which we can specially recommend as having every requisite that could be desired, leaving out the advantages of immediate water-transportation. (See map No. 18.) This site is known as the Augusta tract, situated in Orange and Rockland Counties, New York, and owned by Peter Lorillard, esq., of New York City. It is thirty-eight miles from New York, has an area of 4,481 acres, and is traversed by the Erie Railroad along the valley of the Ramapo. (See map No. 1.)

'That portion of the property west of the Erie Railroad bounded on the east by the line extending from intersection of the northern line with the railroad southward through 'Fox Hill,' 'High Peak,' and 'Ant Ridge,' and bounded on the west by the property of Mead and Shuet, and on the south and north by the 'Sterling estate,' has been selected (an area of about 2,500 acres) as the best adapted to our purposes. (See map No. 1.) This portion of the tract is approached by the wood-road intersecting the 'Orange turnpike' at the 'saw-works,' and leading through a narrow valley to the 'fish-house,' and extending thence along the east shore of Truxedo Lake. A high hill, around the base of which the road winds, guards this approach at the 'saw-works.'

'The line of hills skirting the valley of the Ramapo, of which 'Fox Hill,' 'Ant Ridge,' 'High Peak,' and 'Iron Mine' are prominent points, and the range bordering on Truxedo Lake and its outlets on the west, form, it will be seen, material barriers on the exterior; and as the intervening or interior ground is broken by ravines, and affords natural traverses between which to locate magazines, we have thus all the natural advantages which could possibly be desired.

'As the fall from Truxedo Lake, along the valley of the outlet, is only 80 feet to the saw-works, it will be seen that a railroad to connect with the Erie Railroad at this point can be readily constructed, and thus connect the site with the interior by rail, and with New York City direct by rail, or, via Piermont, by rail or rail and water. The nearest hamlet to this property is Southfields, a wood and water station of the Erie Road, four miles off; the nearest village is Sloatsburgh, two miles below. (See Map No. 1.) The ground is rocky, and this, combined with its hilly nature, renders it unsuited for agricultural purposes, for residences, or for manufacturing settlements.'

"The Augusta tract, however, from the present views of the owners, (see letters of Mr. Lorillard, marked B′ and K″,) may be too costly to enable the Government to secure it, and the board extended its examination, and selected and had surveyed, as next best and available for the purpose, the sites shown in detail in the accompanying maps, alluded to heretofore.

"These sites * * * in the general features of seclusion, character of ground—inclosed by their hilly barriers—ease of connection with the Erie Road, and other essentials approach the perfection of the Augusta tract sufficiently near to render them available for our purpose, provided the former cannot be secured at a reasonable price. In any event the board deem, from the results of its general surveys, that the securement of a suitable site in this section is a foregone conclusion.

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"In concluding this part of the report, it is deemed well to allude to the immediate necessities of a suitable powder-depot for the Atlantic coast.

"In the establishment of our present arsenals, as their locations, at the time of their construction, were but sparsely settled, the erection of powder-magazines on these Government reservations provided for our wants in this respect. The rapid increase of population in the adjacent towns and cities has, however, in the majority of cases, rendered these magazines dangerous to the communities in which they are located, and hence the Government either has abandoned, or eventually will have to essentially abandon, the storage of powder at all of our arsenals. The damp sea-air renders our fortifications unfitted for this purpose, and the Government has now large quantities of powder rapidly deteriorating at these places for want of proper storage-facilities. About 2,500 tons of powder and 3,000 tons of niter are now on hand.

"The necessity of immediate action is hence deemed, it is believed, apparent, and it is earnestly recommended that Congress be asked at its next session to appropriate a sum adequate to purchase a site, and commence the provision of buildings suitable, not only for the storage of powder, but also for our niter supplies, and the accommodation of suitable machinery and appliances for the manufacture of experimental powders.

EXPERIMENTAL GROUND FOR HEAVY ORDNANCE.

"The Department has long felt the want of a suitable site for testing heavy ordnance, obtaining ranges, and solving the various experimental problems connected with the science of gunnery.

"The report of the Chief of Ordnance of 1872 thus alludes to the entire inadequacy of our present facilities in this regard:

'It has been compelled to avail itself of the limited extent of ground near Fort Monroe for the prosecution of these important duties. As the artillery school of practice is established on this reservation, the space is necessarily too contracted for the operation of both. Besides, the range obtained on land is but little more than a mile, and that over the waters of the Chesapeake Bay seldom available; whereas, for efficient experimental purposes, a range of at least six miles is indispensable.

'Some central point convenient to railroad communication, with a suitable extent of level ground, could be readily selected and purchased at a small cost. Experiments with large ordnance cannot be properly conducted without the best and most approved facilities, such as every military nation has found it necessary to provide.'

"The main features that are essential to such a site are that it should be comparatively level, easily accessible, not traversed by highways or extensive water-courses, uninhabited, and sufficiently remote from any settlements to avoid any possible accidents, and embracing an extent of land from seven to eight miles in length and from one-half to one mile in width. It is deemed very desirable by the board that this site should not be very remote from the grand arsenal on the Atlantic seaboard, nor from the powder depot.

"The level beaches and flat interior lands of Long Island and the coast of New Jersey were all, it will be seen by the record, examined.

"The sites examined on Long Island are in the vicinity of Babylon, Deer Park, Bay Shore, and Islip. The ground lies here in extensive level stretches, adapted in this respect for our purposes, but it is deemed objectionable by the frequency of rail and wagon roads, and by the rapidly increasing settlements, rendering early and serious interference, in this regard, highly probable.

"The Jersey coast, extending from Sandy Hook to and including Squan and Island Beaches, consists of level and long stretches of sandy beaches, and the upper end of Squan Beach, in the vicinity of the town of Point Pleasant and Squan Village, has the best local advantages found and examined by the board. This ground has been carefully surveyed, under the direction of the board, by Mr. H. N. Babcock, (see his report marked M',) and a site selected. (See map marked 21.)

* * * * * * *

"The contemplated rail connection would be about two and one-half miles, and its construction would not require any extensive excavation or filling-in, and hence it can be built at a moderate cost.

"The relative location of this site to the grand arsenal and the proposed powder-depot is shown on the accompanying map marked No. 1. An examination of this map will show that ample rail facilities connect this section of the country with the country at large. The present United States life-saving and signal stations, located on the beach, it is believed, will be advantageous to our use of this ground for experimental purposes, while our occupancy will not interfere with these other branches of the public service. The meteorological phenomena of this portion of the coast, such as the force, direction, and frequency of winds and occurrence of fogs, have not yet been fully determined, but all the information in this regard which the board could obtain is presented in the accompanying reports.

"While this site does not possess in the highest degree all the desired requisites, still it is believed to be the best that can be found on the Atlantic coast within a convenient and desirable distance from New York City, the proposed grand arsenal, and the depot for powder.

"The purchase of this site, building the proposed railroad, and purchase of right of way, the erection of the necessary buildings and improvement of the ground, it is thought, will not exceed $100,000, and it is earnestly recommended by the board that Congress be urged to make the necessary appropriations at its next session.

"The Government reservation at Sandy Hook, (see map marked No. 22,) at the entrance of the harbor of New York, distant eighteen miles from the city, and in close and quick communication with it, has an available extent in length of, say, one to two miles, and in breadth of, say, three-fifths of a mile. Its general features are the same as Squan Beach, but it is entirely too contracted for all our uses; and the Long Branch Railroad limits and materially interferes with its usefulness as an experimental firing-ground. However, it is superior in geographical location and equal in other respects to our present facilities at Fort Monroe, and in the interim of the establishment of the experimental ground at Squan Beach it could be utilized (with the permission of the Engineer Department) as an adjunct with Fort Monroe for carrying on such experiments and proof as it may be fitted for and as may be deemed desirable to have conducted at this point.

"S. CRISPIN,
Bvt. Col. U. S. A., Major of Ordnance, President.
"T. J. TREADWELL,
Major of Ordnance.
"T. G. BAYLOR,
Major of Ordnance, Recorder."

NOTE.—The maps and drawings referred to in the foregoing report do not accompany it. They are filed in the office of the Chief of Ordnance.

Statement of the original cost and the estimated market value of lands, buildings, and improvements at the herein named United States arsenals east of the Mississippi River.

Name of arsenal.	Original cost of land, buildings, and improvements.			Estimated market value of lands, &c., as taken from reports of the respective commanding officers.			Remarks.
	Land.	Buildings, &c.	Total amount of cost of land, buildings, &c.	Land.	Buildings, &c.	Total estimated value of lands, buildings, &c.	
Allegheny Arsenal...	$19, 383 71	$287, 645 00	$307, 028 71	$900, 000 00	*$71, 911 25	$971, 911 25	The buildings, in the event of the land being sold in lots, would be of but little more value to the purchasers than for their materials, excepting those in the lower yard for railroad and manufacturing purposes, shops, dwellings, and store-houses.
Pikesville Arsenal...	(†)	Not given.	....	11, 935 00	34, 700 00	46, 635 00	The buildings, if sold without the land, would not bring over $5,000 to $7,000.
Washington Arsenal.	118, 079 97	619, 801 21	737, 881 18	881, 044 31		881, 044 31	A board of assessors appointed by the Secretary of the Interior, in their report, dated March 30, 1872, appraised the lands and buildings at this post at $1,527,850.
Watertown Arsenal..	53, 616 13	473, 286 63	526, 902 76	120, 000 00	310, 000 00	430, 000 00	The amount paid for the purchase of the two first tracts of land is not included in the original cost of the land at this post, as it could not be ascertained from the records of the office—the area of these two purchases is about forty acres. If the sale was forced, the buildings would not bring the price named.
‡ Watervliet Arsenal.	56, 769 27	545, 620 00	602, 389 27	150, 000 00	837, 234 00	987, 234 00	In the event of the land being cut up into lots, some of the buildings would have to be moved from the streets, which would run through the grounds. In the letter, (extract copy inclosed in letter to board on arsenals, &c., of April 1, 1874, marked "D", to the Hon. John Coburn, chairman of Military Committee House of Representatives,") Col. P. V. Hagner states that he estimates that the reservation, laid out into lots 120 by 50 feet, should be worth about $400,000, excluding buildings.

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* This value, being twenty-five per cent. of the original cost, is placed by the Board on Arsenals, &c.

† No record of cost on file at the post.

‡ The original cost of buildings and improvements is not given in many instances, hence the apparent difference between the estimated market value and the original cost.

ENAL

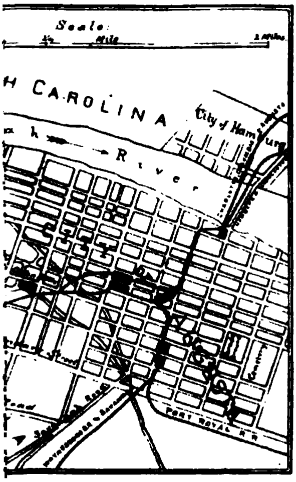
600 700 800 Feet

:S.

ith Shop
erns (underground)
ds
nber Shed
ine House
ns
racks
ers Quarters

ital
House

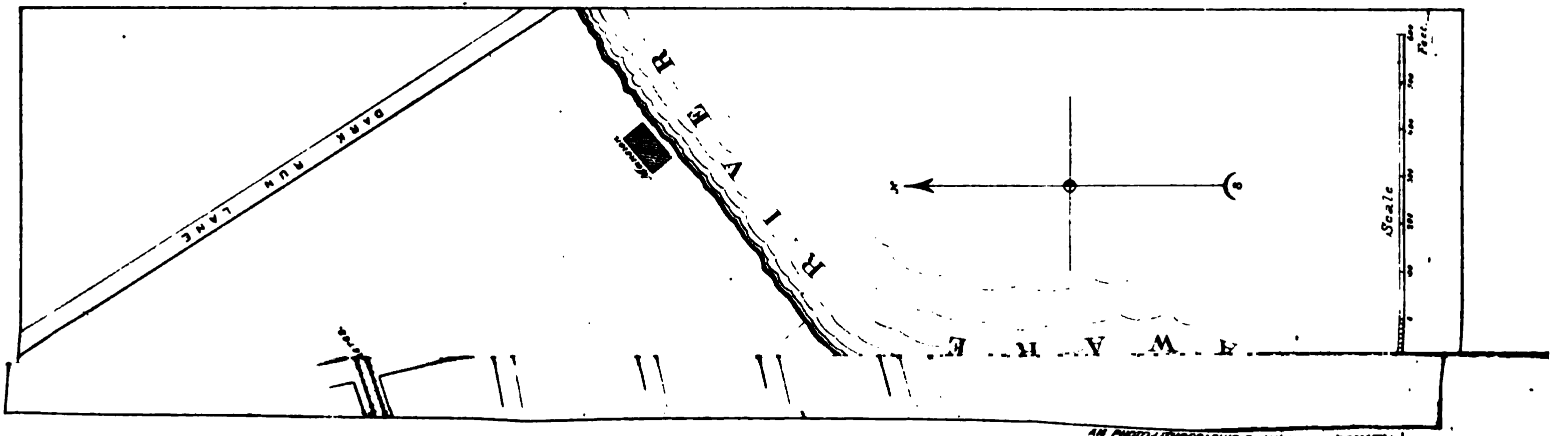
RSENALS,
of Act of Congress
ch 3, 1875.



AM PHOTO-LITHOGRAPHIC CO N.Y. (OSBORNE'S PROCESS)

Nº 4

Nº 5.



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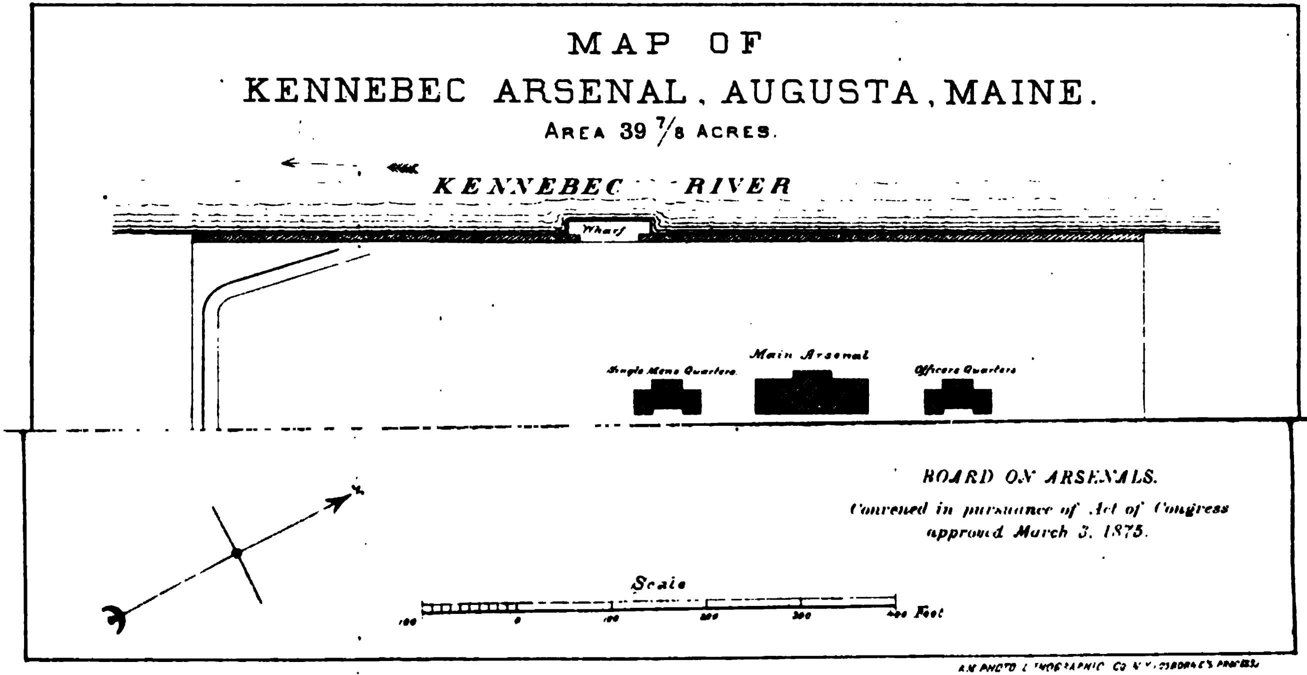


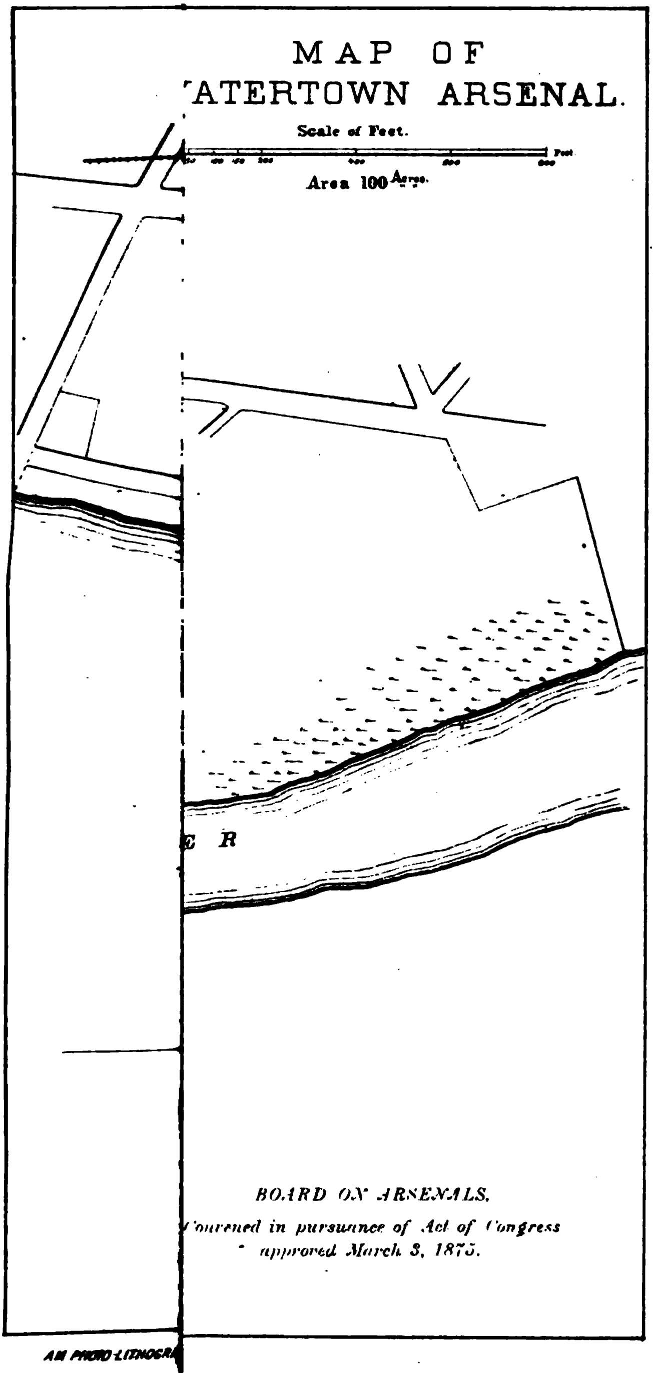
MAP OF
KENNEBEC ARSENAL, AUGUSTA, MAINE.

AREA 39 7/8 ACRES.

BOARD ON ARSENALS.

Convened in pursuance of Act of Congress
approved March 3, 1875.

A.N. PHOTO LITHOGRAPHIC CO. N.Y. (OSBORNE'S PROCESS)



MAP OF
ATERTOWN ARSENAL.

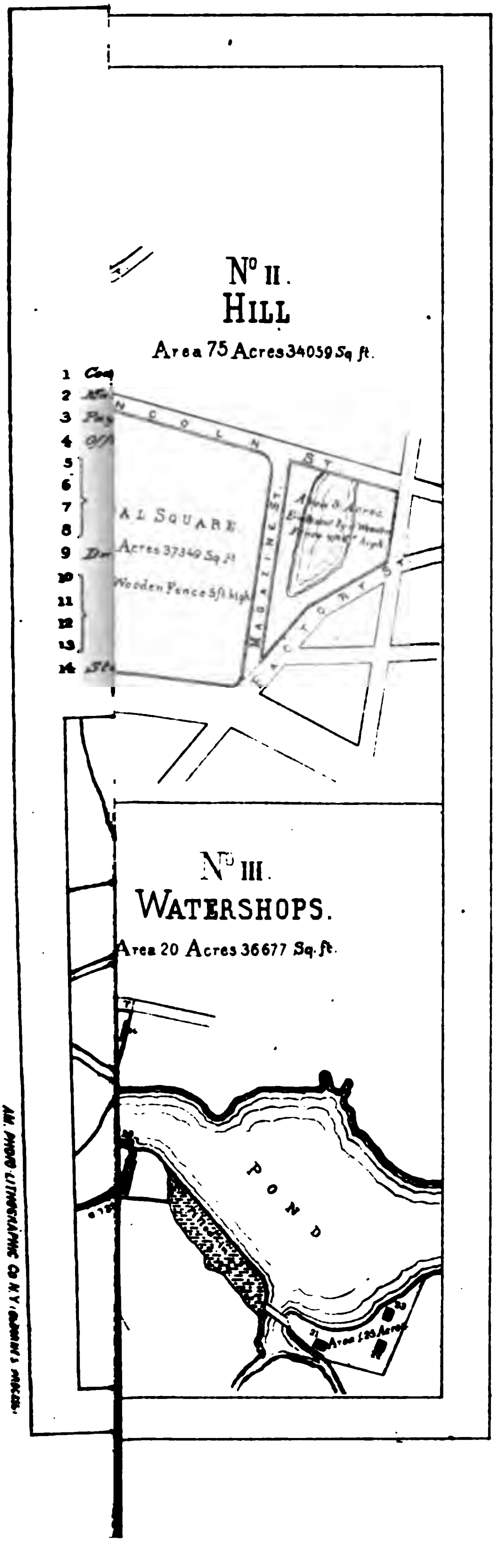
Scale of Feet.

Area 100 Acres.

BOARD ON ARSENALS.
onvened in pursuance of Act of Congress
approved March 3, 1875.

No. 7.

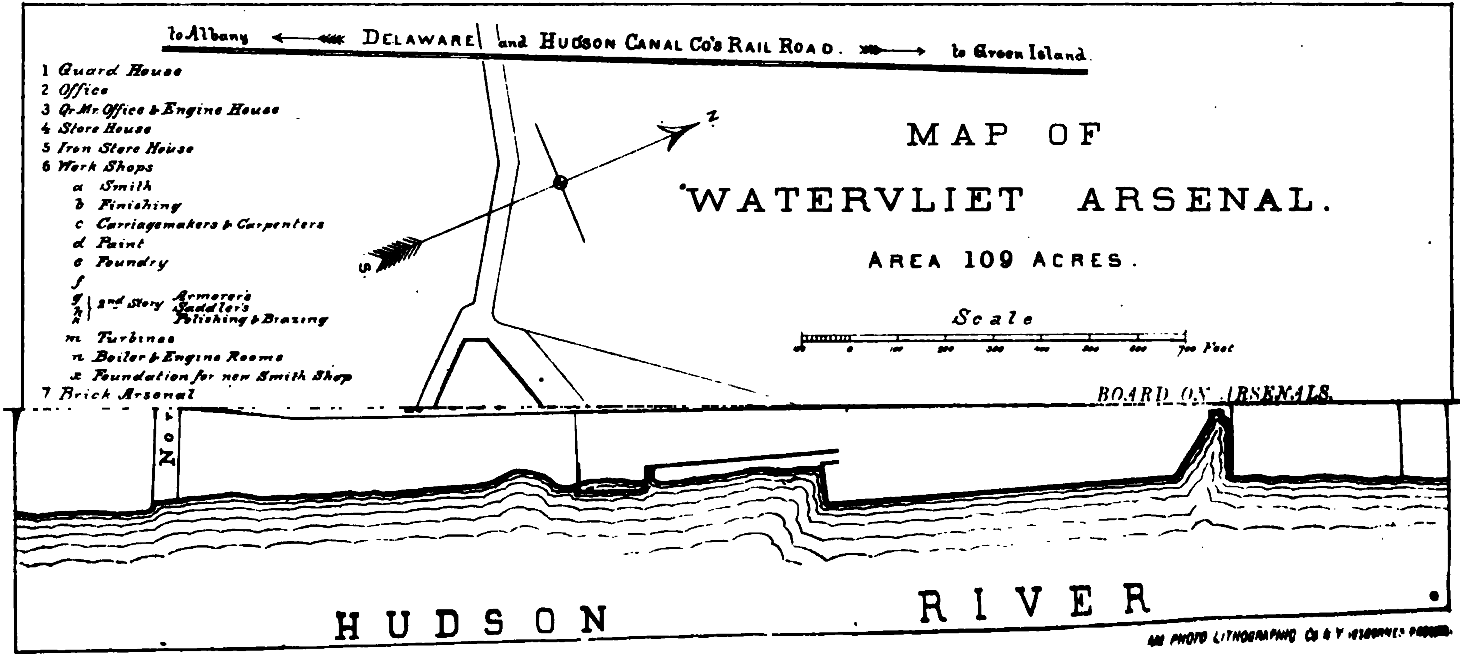
AM PHOTO-LITHOGRA



No. 8.

AM. PHOTO-LITHOGRAPHIC CO. N.Y. (OSBORNE'S PROCESS.)

No. 9.



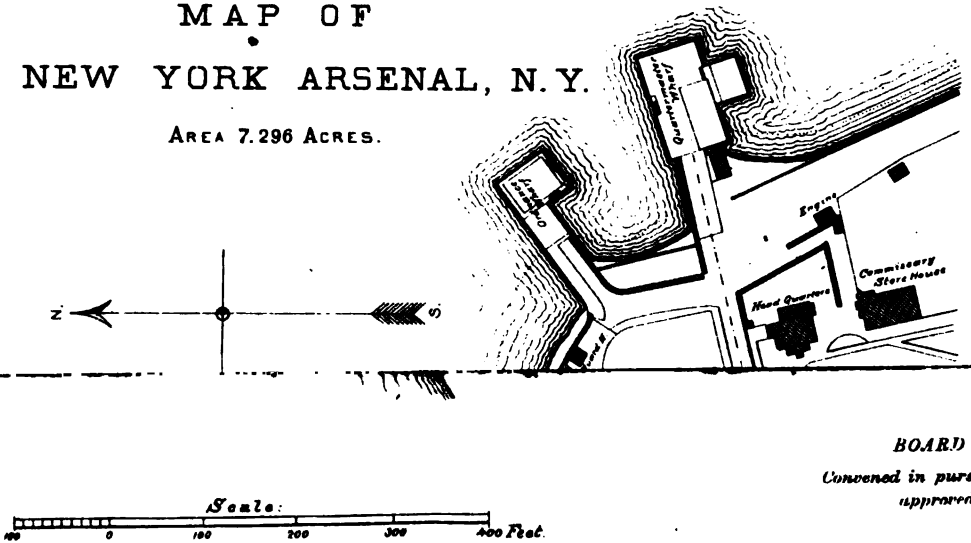
BOARD ON ARSENALS.

AM. PHOTO LITHOGRAPHIC Co. N.Y. (OSBORNE'S PROCESS)

Nº10.

MAP OF
NEW YORK ARSENAL, N.Y.

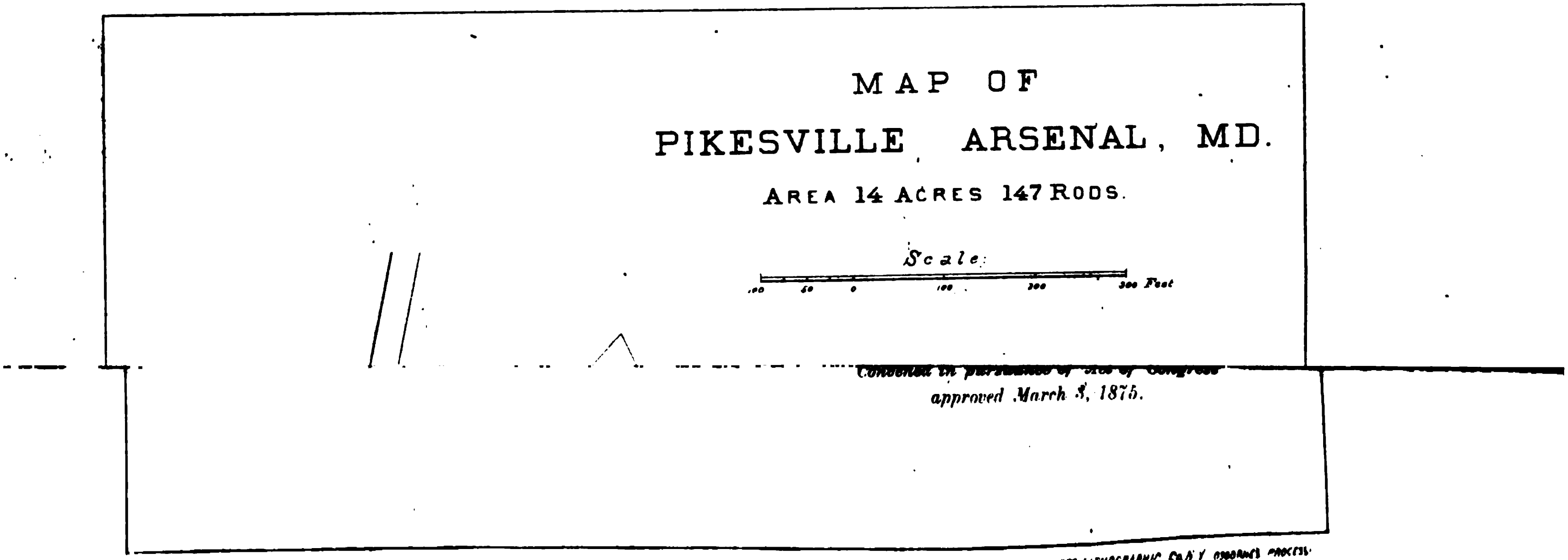
AREA 7.296 ACRES.



BOARD ON ARSENALS,
Convened in pursuance of Act of Congress
approved March 3, 1875.

AM. PHOTO-LITHOGRAPHIC Co. N.Y. (OSBORNE'S PROCESS.)

No. 11.



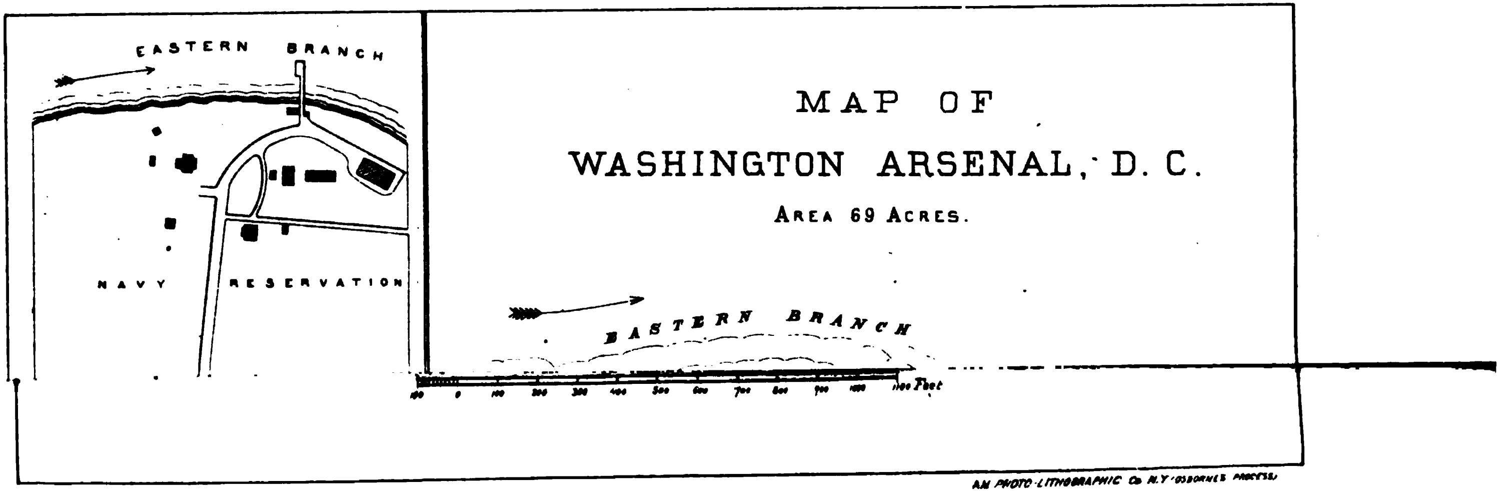
MAP OF
PIKESVILLE ARSENAL, MD.

AREA 14 ACRES 147 RODS.

Condemned in pursuance of Acts of Congress
approved March 3, 1875.

AM PHOTO LITHOGRAPHIC CO. N.Y. OSBORNE'S PROCESS.

No. 12.



MAP OF

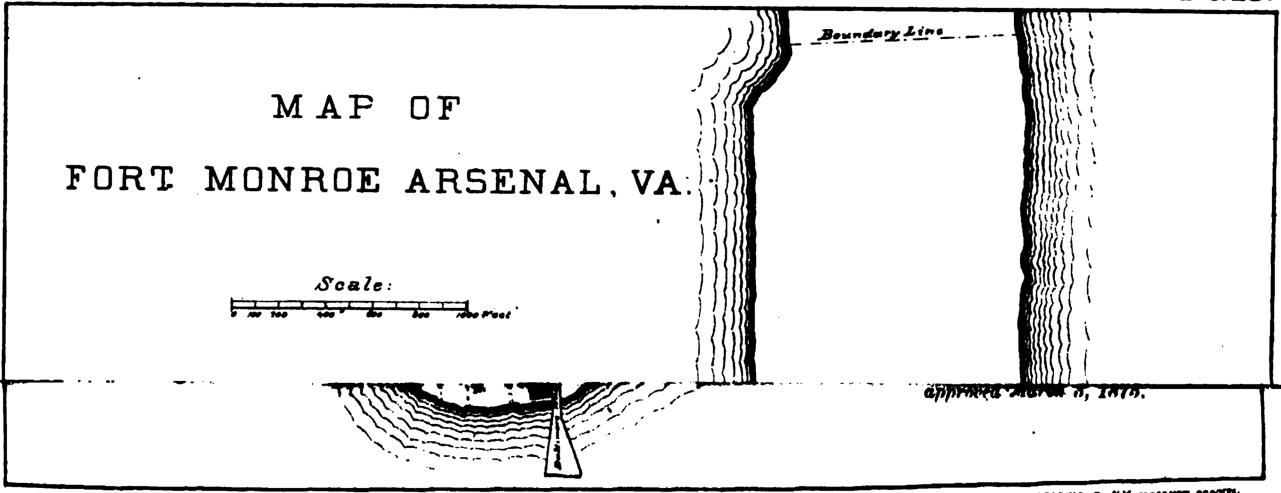
WASHINGTON ARSENAL, D. C.

AREA 69 ACRES.

AM PHOTO-LITHOGRAPHIC Co N.Y. (OSBORNE'S PROCESS)

No. 13.

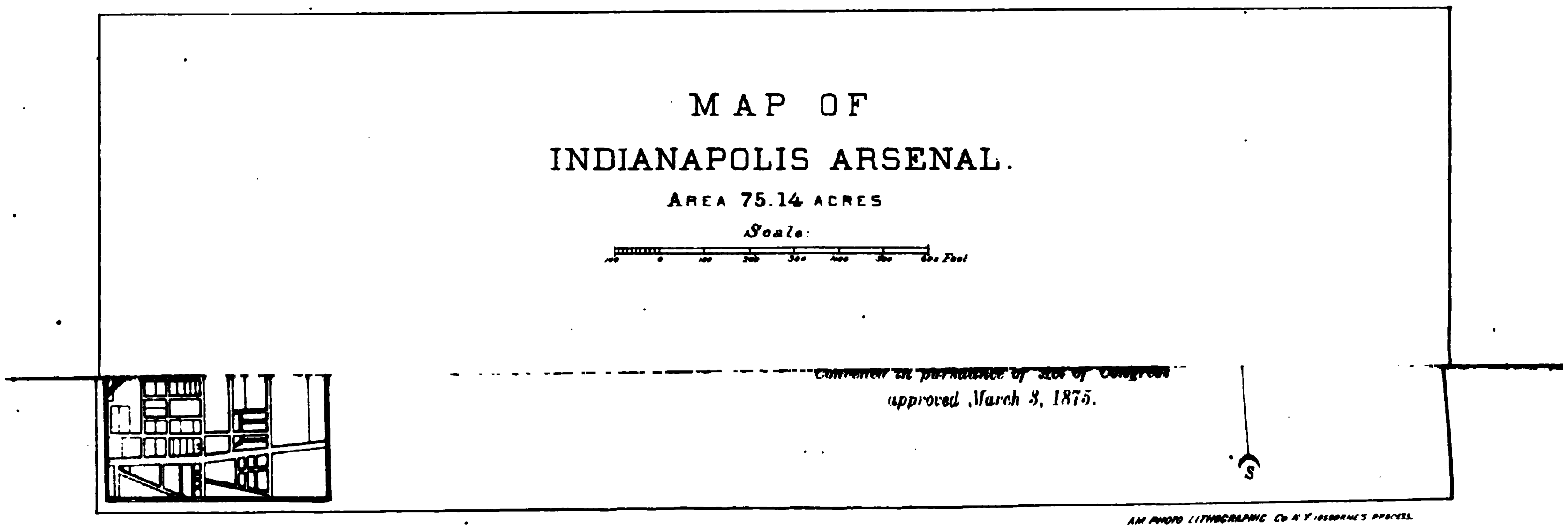
MAP OF
FORT MONROE ARSENAL, VA.



Approved March 8, 1875.

AM. PHOTO-LITHOGRAPHIC CO. N.Y. (OSBORNE'S PROCESS)

Nº 14.



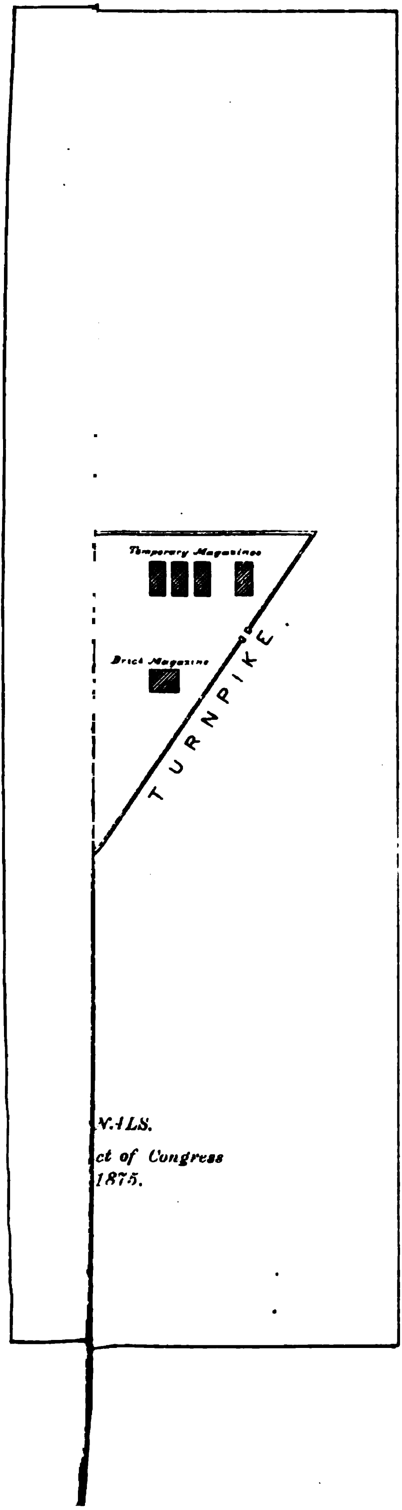
MAP OF INDIANAPOLIS ARSENAL.

AREA 75.14 ACRES

Scale:

Conveyed in pursuance of Act of Congress
approved March 3, 1875.

AM. PHOTO LITHOGRAPHIC Co. N.Y. (OSBORNE'S PROCESS.)



No.16.

AM. PHOTO LITHOGRAPHIC CO. N.Y. (OSBORNE'S PROCESS)

APPENDIX B.

WATERTOWN ARSENAL, *September* 27, 1875.

SIR: I have the honor to call your attention, with the view of bringing the subject to the notice of the Executive and Congress, the great want which is so much felt of a Government powder-mill, under the direction of officers of this Department, for the purpose of experimenting in the fabrication of gunpowder for the military service, and especially of that for heavy guns.

The more study and reflection that is devoted to the consideration of the best means of improving the quality of gunpowder and adapting it to the purposes of modern artillery, the more clearly will appear the absolute necessity of having an experimental mill, where powder can be made under our own directions, and tested promptly by firing service-charges; where experiments can be at all times carried on systematically, and all suggestions having for their object the melioration of our powder supplies can be practically and faithfully tested with every requisite for insuring reliable results.

The time would seem to have arrived when it is imperative on us to take some step toward the attainment of this long-desired end.

The history of the improvements introduced during the course of the last fifteen years in the manufacture of gunpowder in different countries cannot fail to bring conviction to the unprejudiced mind that the possession by the Government of a mill such as has just been indicated is a necessity, and will most surely be productive of beneficial results in raising the standard of all kinds of powder used in the military service.

In 1860, when Captain Rodman made his first experiments at Fort Monroe with his perforated cake powder, and proved by actual trial that a given velocity could be imparted to a shot from a 15-inch gun with very much less strain to the gun when this new powder was used than with any ordinary grained powder, a distinguished Russian officer was present, and witnessed the firings. His reports to his government were so favorable to the perforated cake form of powder that, on his return to his country, he induced the authorities to sanction the preparation of machinery for the manufacture of powder of this kind on a large scale for the use of all heavy guns.

A powder-mill being at his disposal, and being able to take the powder for his purpose at any desired stage of its manufacture, and use it on the spot, he was soon able to inaugurate successfully the fabrication of this powder in quantities to meet all demands for it. It differed from that which Captain Rodman had made only in the size of the cakes, which were smaller, and it is now an article of established manufacture known as "prismatic" powder.

Captain Rodman, not having at his command the facilities which a powder-mill only can supply, never succeeded in making this powder in large quantities, or at a price to be able to call it a great practical success.

There can be little doubt that had he had the advantages of even a small experimental powder-mill, where he could test some of the different plans of making this powder, he would have succeeded as well as the more fortunate Russian officer, and the credit of perfecting as well as originating this invention would have been his.

Finding great practical difficulties in the formation of the cakes with the limited means at his disposal, and not having the powder in the right condition for his purposes, Captain Rodman proposed, as being easier to make, a pellet powder, the grains of which were in shape like a double convex lens. This, too, he attempted to manufacture at an arsenal, but his materials, when he received them from the powder-mills, were not in a favorable condition for compressing, and the production of pellets of uniform density proved to be utterly impracticable, and of course the powder could not give uniform results. It also failed to become a practical success. If the experiments could have been conducted at a powder-mill, with soft-grained powder just from the corning-machine, the results would have been quite different.

Three years ago I was directed to superintend the manufacture of some mammoth powder, to be made at one of the powder-mills, for the Army. Believing the proposed modification to be both feasible and desirable, I endeavored to persuade the manufacturer to make the grains of this powder uniform in size, each a small cube, like the cut white sugar found in market. It was claimed by them that the plan was not practicable, on account of the great expense that it would involve. It was not then known that this proposed powder was identical with the English pebble-powder, the grains of which are formed by means of an inexpensive machine, and is the cheapest of all the powders made in England. Very naturally the manufacturers preferred to fill the order in the same way in which they had been accustomed to fill previous similar ones, following the regular routine, with which all of the workmen were familiar, and securing their regular profit, instead of embarking in a series of untried experiments, involving a considerable expenditure of time and money, uncertain where they should lead or what return bring back. Their own interests taught them to be conservative, to cast their preference to that course which gave the least trouble to themselves, involved no perplexing questions of the best mode of procedure, no change of plans or machinery, and incurred no additional expense.

If an expenditure of time, thought, labor, and money is to be made in furthering the improvement of the quality of gunpowder for the military service, its officers are the proper persons to direct it, and have charge of the work. It cannot be expected that private manufacturers will devote themselves to this aim when their pecuniary interests do not prompt them to it, but rather conflict with all changes from established processes. The officer's professional reputation and the credit he would gain by any marked improvements that he might make would act as a spur to his endeavors instead of checks to restrain them.

In Germany and Russia the government own powder-mills, which are under the immediate direction of officers of the army, whose duties embrace, beside the superintendence of the manufacture of the necessary supplies of all kinds of powder for the army and navy, the constant study and trial of all means that promise to lead to the improvement of its quality.

The introduction of prismatic powder, to the exclusion of all other kinds for use in all large guns, has been definitely settled upon after careful and extended experiments, and the manufacture is conducted on a large scale, commensurate with the demands of the service.

France has within the last few years changed the direction of its powder-mills, placing a certain number of them under officers of the army, who are charged with making the supplies for the military and naval services.

The change of administration has been marked by renewed zeal in carrying on extensive and systematic experiments, having for their object the improvement of the quality of the powder, and making it answer the new requirements arising from the changed circumstances of new and heavier guns.

The broad principle has been recognized that for each gun there is a special powder, which, when fired in that gun, will, without injury to it, do the maximum amount of work, and extensive and costly experiments are now being made to determine this powder for the different guns in use. That which has been adopted for the field-guns is a novelty, and has not been tested elsewhere, so far as I am informed.

England depends for its supply of powder in time of war upon the private mills in the kingdom. The government, however, owns the Waltham Abbey powder-mill, which is capable of making from 14,000 to 28,000 barrels per annum, depending upon the kind of powder. The mill is under the direction of a colonel of the army assisted by two other officers. In this way the government has the means of making any desired experiment as to materials, proportions of materials, the best method of incorporating them, or of conducting any of the processes in order to produce the best results, and also to determine by its own experience the actual cost of manufacture, which is important whenever circumstances require it to become a purchaser. Samples of all kinds of powder made at this mill are sent annually to each powder-mill within the kingdom, and the private manufacturer thus reaps without any expense to himself all of the advantages to be derived from the experiments that have been made at the government mill—an advantage of no small account.

The superior excellence which is rightly accorded to the English powder is mainly due to the influence exerted, and the improvements made, by the government mill—to the valuable experiments made there—the results of which are at once communicated to the private manufacturers.

In England, the solution of the question of a suitable powder for heavy guns was first sought in the manufacture of a solid pellet powder, every grain of which was of exactly the same size and shape, pressed solid in a mold of a particular form. Owing, however, to the great expense of manufacture, a substitute was sought which should possess the same advantages and be free from this objection.

The result of the experiments made for this end was the production of a powder which has given excellent results, and is known as "pebble" powder. It is formed into small cubes by cutting the hard-pressed cake, one-half inch thick, first into long prismatic sticks, and afterward these sticks into cubes.

The cutting is effected by means of a machine perfectly simple in its construction, designed for this special purpose at the Waltham Abbey mill, and so satisfactory in its action that, as before stated, this powder is the cheapest of all of the different powders made.

The private manufacturers reaped at once the benefits of the experience gained in the government mill. They were permitted to copy this machine, and are now able to furnish powder suitable for large guns at a price less than those of other countries.

Such are the advantages that the powder-makers in this country are to derive from the establishment of a Government powder-mill under the direction of the officers of this Department. The mill will be ordinarily employed in making experimental powders with the view of improving the quality of the various kinds, determining the best wood for the charcoal, and the best method of securing uniform results in the products of incorporation, as well as establishing standard powder for each of the guns in service.

The manufacture of powder has not progressed so far as not to leave a wide field for investigations, if we can only obtain the means of carrying on the work. Samples of all of the different kinds of powder manufactured during the year would be distributed annually to every mill throughout the country, with permission to visit and copy any machinery that might be deemed desirable, the results of experiments bearing on the manufacture of powder, and of interest to those engaged therein, would be communicated to them, and in this way they would be the recipients of much useful information without any expense or trouble to themselves. The Government would reap the fruits of the money spent in disseminating this useful information by the improved quality of its powder-supplies in times of war, and the higher standard of excellence of all kinds of powder.

In times of war the powder-mills would find full employment in supplying the Government's wants, and would be better able to furnish powder of the quality required, as they would be called upon to make it according to certain standard samples, the different processes to accomplish it being laid down for their guidance from actual experience at the Government mill.

The interests of the powder-makers in the establishment of this proposed mill are identical with those of the Government, and they can well afford to join hands with us in obtaining favorable legislation for carrying it out.

I have conversed with the officers of two of the large companies engaged in the manufacture of powder, and they agree with me in the opinion that a Government mill, such as is herein proposed, would be of great advantage to the Department, and would in no may conflict with their interests. Though they may not deem the matter of sufficient importance to enlist their active co-operation in procuring the necessary legislation to start the mill, they will at least do nothing to oppose the measure or thwart our efforts.

I regret that I have not had the opportunity of conversing with the officers of the other two large companies on this subject, but from their known enlarged views we may expect that they will entertain similar opinions, and pursue the same course of action as those first mentioned.

Very respectfully, your obedient servant,

T. T. S. LAIDLEY,
Colonel of Ordnance, Commanding.

The CHIEF OF ORDNANCE.

APPENDIX C.

BENICIA ARSENAL, CAL., *July* 21, 1875.

GENERAL: I have the honor to submit the following as a detailed report of the work performed in boring the artesian well at this post during the past fiscal year.

So many difficulties had been encountered and overcome during the previous year that the work was continued with greater confidence than ever before. Experience had taught the lesson that we could not expect great results at once, but that no means which had been adopted were capable, little by little, of ultimately accomplishing our purpose.

We have met with one difficulty, however, not experienced previously, which could not be overcome, and that was the want of funds to continue the work during the months of April, May, and June. This deficit in the appropriation resulted from the necessity of increasing the daily work to fifteen hours, and paying the men for the extra hours they were employed. The change in the work-hours was the result of thought and trial. It was ascertained that during the time the men were working at the well no sediment settled around the outside of the pipe, and therefore, by increasing the time during which the pipe was subjected to the friction of the tools, in ascending and descending, and to the movement of the mud and water in the bottom of it by the use of the drill or pump, the attraction of the soil to the outside surface of the pipe was lessened. By comparing the distance for which this 8-inch pipe has been used with that to which the 11 and 9 inch pipes reached, you will see that the above is correct. The first of these stopped at the depth of 202 feet, having a surface of 579 superficial feet in contact with the soil; the second was 557 feet long, and had 836 superficial feet pressing against the earth, when it could be moved no farther. The present pipe is 960 feet in length, and, of this distance, 403 feet are in contact with the soil—it therefore had 844 superficial feet of its surface surrounded by *débris* when it became immovable.

The success that was experienced with this pipe reaching a greater depth than the others was due entirely to the constancy of the work at the well, in comparison to that done previously.

I have therefore concluded that the best method of boring an artesian well is to work without cessation night and day.

The work has been continued for nine months. If we had had the money for twelve months' work the month of April would have been occupied in making new tools and pipe of a reduced diameter, so that only two months have been lost from actual boring.

In July the work was continued with the 8-inch tools and pipe. On the 11th the tool struck a bowlder, which broke the side-cutters. The strata pierced consisted of shale, sandstone, bowlder, and hard quartz-ore rock, with lime-seams through it. The tubes of the boiler, thirty-two in number, were worn out, and had to be replaced; and the steel-wire rope for hoisting-pump had rusted, so that 400 feet of it were condemned and new rope substituted. Four days were lost in making these repairs; but 187½ hours were employed in boring, which gave as a result 25 feet 7 inches.

In the month of August strata of siliceous shale and sand-rock were bored through, until the 22d, when a bowlder was encountered. As there is nothing to warn the workman when he will meet with one of these ugly customers, his tools have to suffer; and, in this case, both side cutters were broken. While they were being raised out of the well a new lever was put up, and the hoisting-gear was overhauled. The cause of the steel-wire rusting so rapidly was attributable to the fact that the rope had a hempen core, which absorbed the water every time the pump was lowered into the well, and this kept the wires constantly supplied with moisture, even when the rope was wound on the reel. A new steel-wire rope was ordered, with a core composed of soft iron wires, all of which were to be tarred before they were put together. As this had to be manufactured, the work went on with the old rope until it broke. Two hundred and seventy-three hours wereemployed in boring, and the progress make this month was 61 feet

The work was commenced in September with every prospect of success, as the amount accomplished in August was encouraging; but the result, as will be seen, proved a disappointment. On the 3d the tools were lowered three times, and on each occasion they could not be turned in the well. A distance of nearly 3 feet was filled in with hard rock, and the boring of the previous day had to be repeated.

After the second shift of work on the 7th, the side-cutter tool was drawn out of the well, leaving them and the plates behind it. The extraction of these four pieces, as they were united to each other, was attempted with a hook, but failed; and the more strain exerted, the more firmly they resisted; it was therefore found necessary to break them apart, and to employ the kit-extractor to raise them.

The next detention resulted from the wear of the shoulders of the side-cutter tool. They commenced to yield, and another frame had to be made.

By the 25th the tool was ready and the work resumed, but on this very day, to distinguish this month for accidents, the main pin holding the plates together and three of the pins which hold the side cutters to the plates were broken in the first shift; but the drill, fortunately, brought up the whole system, held by one small pin. The half stroke was tried the next day, on account of the hardness of the rock in which the drill was working, but with very little success. It was concluded, however, from the want of resistance when the drill was turned in the well, and the even stroke obtained in all positions of it, that the hardest portion of the rock had been perforated. This was also proved by the appearance of the tools when they were taken out of the well, which showed evidently that they were no longer grinding the rock.

On account of the many breakages, I was desirous of using the reduced stroke, which would certainly obviate all difficulties of this nature, considering that the reduced stroke and less progress in a given time would be preferable to breaking tools.

Theoretically, it seemed that half a stroke must do some work, as drops of water wear a stone, but practically it proved of no avail, especially when the drill was piercing a stratum which was not homogeneous. In this case the drill does not work evenly on all sides, and will affect the soft places of the bottom the most, wearing them away first, and thus rendering each subsequent stroke on them longer. The harder portions of the rock remain as elevations in the bottom, from which the drill glances; it is then necessary to fill in with hard rock and commence gradually to drill down on the top of these and work them away.

The greatest daily progress, 2 feet 6 inches, and the least, 3 inches, were obtained in the same time, *i. e.*, fourteen and a half working hours. The total progress in the month was only 10 feet.

The work during the first days of October raised our spirits and we indulged in great hopes for the future. On the first day, notwithstanding seven hours were occupied in removing small bits of steel, which had remained in the well ever since the accidents of September. the progress was good.

The third day was the bright day of the year. More work was performed in fourteen hours than was ever accomplished in the same time before. The well was sunk 4 feet 9 inches. This was an extraordinary success, as it was obtained at a depth of 756 feet. As far as I can learn, this progress has never been equaled at so great a depth and through a similar stratum of rock. The progress on the 23d was again 4 feet 9 inches, but the time occupied in making it was one-half hour longer than that employed in obtaining the same result on the 3d. The whole progress made this month was 79 feet. This was regarded as an excellent month's work, as we lost five days by the following accidents: two side-cutters and the wire rope were broken, and the sheave of the pulley in the top of well-tower was cracked.

Misfortune commenced with November. The drill struck a hard stratum on the fourth day and broke both side-cutters, leaving them in the well; on the next day only 6 inches in depth were gained, after working fourteen hours and a half. Water made its appearance over the top of the pipe on the 18th of this month, and immediately the drill encountered a very hard stratum of rock 6 feet and 2 inches in thickness. It was apparent from this that the water obtained had percolated through the shale and sandstone which overlay this formation, until it met this rock, which stopped its progress downward, and that as soon as an opening was made it sought its level. While working in this stratum with a reduced stroke two side-cutters were broken, and the drill and side-cutters had to be renewed fifteen times. I would state here what experience has taught us in reference to working through these hard seams of rock. The best method is to use the drill first with the full stroke of 20 inches—this can be done in the hardest rock without materially damaging it—and, after you have pierced the stratum, to enlarge the hole with the side-cutters at a reduced stroke. The progress made this month was only 40 feet and 11 inches.

I was absent during the month of December, and my knowledge of the work is derived from the daily reports of the machinist in charge. An accident occurred on the 8th. One of the rods broke in the well, and the whole system with the tools had to be raised with a tool made for the purpose. At the depth of 922 feet, just one month after the time that water had been obtained in November, the drill opened a stream of water which flowed over the top of the pipe, furnishing a supply of 3,000 gallons in twenty-four hours. The quality of the rock through which this water flowed could not be ascertained, as all the boring-dust was carried off subterraneously; but this proved that it was a stream of water, as it had an outlet. This was soft water; and the fact of obtaining it was very encouraging, as it gave us hopes of reaching a stream of greater magnitude which might furnish an adequate supply of water. The progress made this month was 63 feet and 5 inches, and the work done was very satisfactory.

A series of accidents interrupted the work during the first part of the month of January. Hardly any progress was made until the 8th, some of the reports reading as follows: "2 inches in thirteen hours," "10 inches in fifteen hours," "11 inches in fourteen hours," &c. Now, considering that six men and a steam-engine were at work constantly, these nightly reports were rather discouraging to all who were interested in the progress of the well; but perseverance was crowned with success, and the drill finally reached the soft rock. On the 20th of the month we commenced to have great difficulty in moving the pipe, and seven days after it was impossible to push it down or pull it up, although two hydraulic-pumps of fifteen tons capacity were used.

The progress made this month was 38 feet and 4 inches, and the well was piped to a distance of 950 feet from the top. As we could move the pipe no farther, it was determined to resign the use of the side-cutters and to continue the use of the drill until the caving of the wall of the well prevented our using this diameter of bore.

In February the number of working hours, which had been increased in order to keep up the motion of the pipe as long as possible, and which motion tended to keep it loose, were reduced, now that the pipe had become stationary.

The drill bored without the side-cutters in this reduced time the same distance as when the work was continued to fourteen hours with them. The steel ring on the bottom of the pipe became partially detached on the 23d, when it was cut off it assumed a position across the pipe, the plane of the ring being vertical.

A singular occurrence happened at the instant that the pipe was freed from the ring, a large amount of gas rushing up. When the bottom expanded, being relieved from the confinement exercised by the ring, this gas escaped to the interior of the pipe through some of the seams which had been opened. After the ring was removed the pipe was pressed down 10 feet, notwithstanding its jagged ends, until it rested on the shoulder in the well-hole which was formed by the drill making a smaller bore than the side-cutters had done.

The progress made this month was 48 feet and 5 inches, and the strata penetrated was, as usual, hard rock, sand rock, and shale.

We commenced work in March by cutting off the projections in the bottom of the pipe, and forcing back the ragged ends against the walls of the well; on the third, while boring at a depth of 1,037 feet, some part of the free-falling apparatus broke in the well, and the whole system of rods wedged tightly at a point near the bottom when we attempted to raise it. This was the most serious accident that had ever happened, as the rods were only 1 inch square, and we did not dare to exert much force to extricate them.

As the system of rods could be pushed down to the bottom and then raised to this point, we concluded to attach them to the lever, and commence a churning-process up and down through this small space. Finally, to our great relief, the distance through which the rods could be worked appeared to increase, and our dread of failure was relieved. This motion was continued until something else gave way below, and the whole system was raised, except the tongue of the free-falling apparatus. It was this tongue which, wedging between the tool and the walls of the well, had fastened the former so completely.

An accident of a similar character happened on the 15th; on lowering the pump it remained fast, and could not be moved. After trying the steel-wire rope to its full tensile strength, and failing to stir the pump, we used the rods; in attempting to lift it with them, the coupling on pump-rod broke short off, and left the pump in the well; we raised it finally by using the hydraulic pumps and the rods.

The walls of the well commenced caving badly, and during the night of the 24th the well was filled up to a distance of 4 feet from the bottom. The progress in deepening the well was slow, as it took a long time to clean out the well each morning before the drill could be used; and, in many cases, the *débris* had been settled so compactly by the water, that we had to drill through it before the pump could be used to any advantage. The pump was now used more than the drill, and on the 26th the steel-wire rope broke, and the pump, with 500 feet of the rope, sunk to the bottom of the well. It was ascertained, on remedying this, that the steel-wire rope was so much rusted that it was unfit for further use. The progress this month was 27 feet, and work at the well ceased for the want of money to carry on further operations.

Drilling without piping answered for 80 feet, but at the depth of 1,030 feet the drill penetrated a stratum different from any previously encountered—one indicating a volcanic origin. This rock presented a honeycombed appearance, and the water seemed to penetrate its pores; we thus lost an auxiliary in the pressure of the water against the sides of the well, which had been depended upon to some extent to prevent the walls from caving. This rock absorbed the water or allowed it to pass off, and the walls were thus relieved from the pressure of thirty-three atmospheres. As this caving could not be prevented, and as no further progress could be made while it continued, there was evidently no advantage to be gained by working under these circumstances.

It was now necessary to adopt one of two plans; either to commence with a new pipe of a diameter less than 8 inches and to manufacture tools suitable for it, or to put in a piece of pipe to extend from the bottom of the present pipe down to a hard stratum, in which there would be no caving. This pipe, which is called a "last-pipe" by well-borers, must be provided with a steel ring at both extremities; the one at the bottom would be required to furnish a solid bearing on the rock, and the other, made in the shape of a funnel, is requisite to protect the upper edge from the tools, and to facilitate their introduction into the pipe.

In this instance it would have to be at least 110 feet long to reach from the bottom to a sound part of the pipe now in the well, and it should not exceed in its internal diameter 7¼ inches. The objection to adopting this plan consisted in the fact that it might prove useless, as we could not tell how long the caving of the walls would continue. After lowering the last pipe and boring 10 feet farther the caving would, in all probability, recommence, and it would be necessary to raise and lengthen this pipe, which is always a very difficult operation, as it is funnel-shaped and enlarged at the top. If we could keep the well-hole clear of *débris* and continue to drill until a hard stratum of rock was reached, then the length of the last pipe to be inserted would be a known quantity, and this plan of using such a pipe might be worthy of adoption.

It was determined, however, to employ the first plan as the safest and most economical. But before we could commence work again the following articles had to be manufactured, *i. e.*, 1,150 feet of pipe, and a side cutter-frame of a new pattern, as the present one could not be reduced in diameter without weakening it too much; the other tools also had to be turned down to fit the pipe.

I ordered a new rope for the pump, and directed that a zinc wire should be placed in the core, which might tend to prevent the oxidation of the steel wires.

A difficulty now suggested itself to us, *i. e.*, that the old steam-engine hitherto used could not do the work much longer, unless some modification was made in the weight of the rods and tools, their weight being 5,072 pounds. It was determined to reduce this weight by substituting for a portion of the rods fir-poles 2½ inches square. As long as these were kept well oiled, so as not to absorb water, they would act as floats and lighten the whole system of rods and tools, enabling us to continue the work without incurring the expense of purchasing a new engine. The following plan of saving some of the pipe now in the well was considered worthy of trial. The well is doubly lined for a depth of 550 feet, and the upper portion of the pipe—say, 500 feet—could be removed without injury to the well.

Now, as our new pipe cannot, judging from past results, reach more than 500 feet below the present bottom of the well, the new pipe might be made 1,050 feet long, and then this 500 feet of old pipe could be connected with it by a taper joint, and the well might then be lined for a distance of more than 1,500 feet without making any more new pipe than the quantity already mentioned. We attempted to carry out this idea, and made a tool with which the pipe could be cut through at any depth; but, on the application of sufficient force to move it, the pipe broke in pieces, the rivets which held the different joints together giving way.

Water continues to flow occasionally over the top of the pipe, which is 2 feet above ground. This is artesian water, for its character is entirely different from any water obtained in the neighborhood, and it must come from a great depth, as the unusual drought of this season, due to the small rain-fall of last winter, would prevent mere surface-water from rising to such a height.

As above stated, this flow is remitting, and no reason can be assigned for it; it does not correspond with the time of the tides, and the cause of this irregularity must be at some distance from this arsenal.

As the well is sunk, its greater depth, from time to time, influences, of course, the actual progress attained in a given time. For instance, when the work is continued for fourteen hours during the day, eight hours of this time is occupied in cleaning out the well and raising and lowering the tools, leaving only six hours for boring.

The time occupied in the different portions of the work has increased in a direct ratio to the distance from the surface at which the work is performed.

When we discontinued our operations, it took fifty minutes to lower, and one hour and five minutes to raise, the drill.

The progress made in nine months this year is greater than that made in either of the previous years.

During the first year we made 318 feet; in the second, 337 feet; and in this one we accomplished very near 400 feet.

It is impossible to arrive at any definite conclusion in regard to the success of our work, for boring a well in this country is very similar to mining. Here, with us, all nature seems to have suffered an upheaval from some great volcanic convulsion, and geology is at a loss and has no data on which to predicate results, depending upon the regular formations of strata in the different periods of the world's age.

The greatest depth to which an artesian well has been bored is 4,194 feet. It was sunk to this depth to obtain salt for the inhabitants of Prussia. We hope, however, to attain water before reaching such a distance.

The well at Grenelle, near Paris, cost eight years' labor. Its depth is only 1,806 feet, and it yields 600,000 gallons of water per day.

As will be seen by this report, the progress of the well at this arsenal compares favorably with that obtained by the great engineer who bored at Grenelle, and we therefore feel encouraged to continue our work, trusting that at no far distant day we too may reach the much wished-for result of our labors, and obtain a supply of water equal to his in quantity.

Respectfully submitted.

J. McALLISTER,
Lieutenant-Colonel, Ordnance Department.

General S. V. BENÉT,
Chief of Ordnance, Washington, D. C.

APPENDIX D.

Proceedings of the board of officers convened under Special Orders No. 120, *A. G. O.*, 1874, *on infantry-equipments, and materials and supplies necessary for efficient outfit of infantry-troops in field and garrison; with the action of the War Department thereon.*

ORDNANCE OFFICE, WAR DEPARTMENT,
Washington, May 27, 1874.

SIR: Since the introduction of breech-loading small-arms using metallic ammunition, and of a caliber different from that in use during the late war, the subject of a proper equipment for the infantry-soldier has been made a study by this Department, and with a view to ultimate perfection in design and manufacture, and to increase the comfort and endurance of the soldier, many modifications and radical changes have been tested by the troops in the field during the last few years.

It is believed that sufficient data and experience have now been gained to justify the appointment of a board of *infantry* officers to which this data and the results of this experience should be submitted for consideration, with directions to recommend the adoption of an equipment best suited to troops serving as infantry, and in addition determine on such material and supplies as may seem necessary for the efficient outfit of infantry troops in the field and garrison.

If the appointment of such a board is authorized, I have the honor to suggest that it be convened at some frontier infantry post, and that it be composed of officers who have had extended experience in the use of the experimental infantry equipments issued under the recommendations of the board of officers convened by Special Orders 433, War Department, Adjutant General's Office, of 1871, and that this Office be authorized to lay before the board all reports, patterns, &c., that may be essential to a proper understanding of the subjects submitted for its consideration, and the board to call on infantry officers for such further information as they may deem necessary.

The board to make its report to the Chief of Ordnance.

Very respectfully, your obedient servant,

S. V. BENÉT,
Acting Chief of Ordnance.

The Hon. the SECRETARY OF WAR.

JOURNAL OF BOARD.

Proceedings of a board of officers convened at Fort Leavenworth, Kansas by virtue of the following order:

[Special Orders No. 120.—Extract.]

WAR DEPARTMENT, ADJUTANT GENERAL'S OFFICE,
Washington, June 1, 1874.

14. A board, to consist of Lieut. Col. W. R. Shafter, Twenty-fourth Infantry; Lieut. Col. A. McD. McCook, Tenth Infantry; Lieut. Col. Thomas C. English, Second Infantry; Maj. Alexander Chambers, Fourth Infantry; Captain M. H. Stacey, Twelfth Infantry, is appointed to meet

at Fort Leavenworth, Kansas, on the 1st day of July, 1874, or as soon thereafter as practicable, to consider and report upon the subject of a proper equipment for the infantry-soldier, and to recommend the adoption of an equipment best suited to troops serving as infantry, and in addition to determine on such material and supplies as may seem necessary for the efficient outfit of infantry-troops in the field and garrison.

The Chief of Ordnance is authorized to lay before the board all reports, patterns, &c., that may be essential to a proper understanding of the subjects submitted for its consideration, and the board is authorized to call on infantry officers for such further information as they may deem necessary. The board will make its report to the Chief of Ordnance.

The junior member of the board will act as recorder.

By order of the Secretary of War:

E. D. TOWNSEND,
Adjutant General.

FORT LEAVENWORTH, KANS., *July* 1, 1874.

The board met pursuant to the foregoing order.

Present, Lieut. Col. W. R. Shafter, Twenty-fourth Infantry; Lieut. Col. A. McD. McCook, Tenth Infantry; Lieut. Col. Thomas C. English, Second Infantry; Capt. M. H. Stacey, Twelfth Infantry.

Absent, Maj. Alexander Chambers, Fourth Infantry.

The board directed the recorder to apply to the assistant adjutant-general, department of the Missouri, for a suitable place to hold its sessions; also, for an orderly, a clerk; and then adjourned to meet to-morrow, July 2, at 10 o'clock.

FORT LEAVENWORTH, KANS., *July* 2, 1874.

The board met according to adjournment.

Present, Lieut. Col. W. R. Shafter, Twenty-fourth Infantry; Lieut. Col. A. McD. McCook, Tenth Infantry; Lieut. Col. Thomas C. English, Second Infantry; Capt. M. H. Stacey, Twelfth Infantry.

Absent, Maj. Alexander Chambers, Fourth Infantry.

Communications were received from the Acting Chief of Ordnance, United States Army; First Lieut. George H. Palmer, Sixteenth Infantry; Capt. Thomas M. Deane, ordnance stoor-keeper, Watervliet Arsenal; Capt. J. A. Snyder, Third Infantry; Conrad Blattner, late sergeant Nineteenth Infantry; First Lieut. James Regan, Ninth Infantry, and ordered to be filed for future reference.

Awaiting the arrival of Major Chambers, the board adjourned to meet to-morrow at 10 o'clock.

FORT LEAVENWORTH, KANS., *July* 3, 1874.

The board met pursuant to adjournment.

Present, Lieut. Col. W. R. Shafter, Twenty-fourth Infantry; Lieut. Col. A. McD. McCook, Tenth Infantry; Lieut. Col. Thomas C. English, Second Infantry; Capt. M. H. Stacey, Twelfth Infantry.

Absent, Maj. Alexander Chambers, Fourth Infantry.

The board then resolved to conduct its proceedings in the following manner:

1. To have the room of meeting prepared with racks and appliances,

so that all patterns of equipments submitted to the board for examination may be at all times exposed in the room where the sessions are held.

2. The examination of all patterns of equipments submitted to the board.

3. Reading and an examination of all reports from officers, soldiers, and citizens submitted to the board.

4. A practical test of all the different patterns of equipment examined.

After some further preliminary business, the board adjourned to meet on Monday, July 6, at 10 o'clock.

FORT LEAVENWORTH, KANS., *July* 6, 1874.

The board met pursuant to adjournment.

Present, Lieut. Col. W. R. Shafter, Twenty-fourth Infantry; Lieut. Col. A. McD. McCook, Tenth Infantry; Lieut. Col. Thomas C. English, Second Infantry; Capt. M. H. Stacey, Twelfth Infantry.

Absent, Maj. Alexander Chambers, Fourth Infantry.

A telegram was received from Major Chambers, stating that he would be here to-day.

Also, a communication from Conrad Blattner, in reference to his kit. Submitted to the board and filed.

Also, one from Capt. J. Ford Kent, Third Infantry, in reference to cartridge-boxes.

Also, one from Capt. Clifton Comly, Ordnance Department, inclosing invoices and receipts for certain articles of ordnance-stores submitted for the inspection of the board.

Also, one from A. D. Laidley, informing the board that he had shipped by express a model of his revolving cartridge-box.

All ordered to be filed for future reference.

The board directed that a communication should be addressed to First Lieut. S. McKeever, Second Infantry, requesting him to furnish a cartridge-box of the same pattern as that already presented, but of a smaller size, to contain twenty cartridges.

The board then proceeded to examine in detail the various articles of equipment furnished for inspection, a description of which is hereunto appended, and then adjourned to meet to-morrow at 10 o'clock.

FORT LEAVENWORTH, KANS., *July* 7, 1874

The board met pursuant to adjournment. Present, all the members.

Major Chambers submitted a statement in writing, explanatory of his absence.

The board continued the examinations begun yesterday, and then adjourned to meet to-morrow at 9 o'clock.

FORT LEAVENWORTH, KANS., *July* 8, 1874.

The board met pursuant to adjournment. Present, all the members.

Lieut. George H. Palmer, Sixteenth Infantry, appeared before the board and exhibited an improved neck-yoke valise and haversack, and gave a practical exhibition of its value as compared with others.

The board continued the examination and discussion of the articles of equipment presented for examination, and at 3.30 p. m. adjourned to meet to-morrow morning at 9 o'clock.

FORT LEAVENWORTH, KANS., *July* 9, 1874.

The board met pursuant to adjournment. Present, all the members.

The examination and discussion of the articles of equipment presented for consideration was continued.

Lieutenant Palmer was again before the board, and gave a further exhibition of his equipment, two sets of which were afterward sent to the commanding officer of Fort Leavenworth, for trial among his men.

A circular was prepared, requesting commanding officers of artillery and infantry regiments to give their views relative to the outfit of soldiers acting as infantry.

The board, at 3.30 p. m., adjourned to meet at 9 o'clock to-morrow morning.

FORT LEAVENWORTH, KANS., *July* 10, 1874.

The board met pursuant to adjournment. Present, all the members.

A sample of cartridge-box was received from A. D. Laidley, and submitted to the board. Also, a pattern knapsack-supporter, from D. C. W. Baxter; submitted to the board; described elsewhere.

The board then deliberated upon what should comprise an infantry soldier's equipment in the field.

A letter was addressed to the Adjutant General of the Army, asking what was intended to be embraced by this sentence, in paragraph 14, S. O. No. 120, convening the board: "and, in addition, to determine on such material and supplies as may seem necessary for the efficient outfit of infantry troops in the field and garrison."

The board, at 3.30 p. m., adjourned to meet to-morrow at 9 a. m.

FORT LEAVENWORTH, KANS., *July* 11, 1874.

The board met pursuant to adjournment. Present, all the members.

A communication was received from Col. N. A. Miles, Fifth Infantry, stating that he had no competent clerk available for detail for the board; whereupon the board adopted the following resolution:

Resolved, That application be made to the Adjutant General United States Army for authority to hire a civilian clerk.

The board, at 2.30 p. m., adjourned to meet on Monday, July 13, at 10 o'clock.

FORT LEAVENWORTH, KANS., *July* 13, 1874.

The board met pursuant to adjournment. Present, all the members.

A letter was received from the Chief of Ordnance, informing the board that an improved cartridge-box of Lieutenant McKeever had been forwarded by express.

The board examined reports from commanding officers of infantry companies on new ordnance-equipments, and at 4.30 p. m. adjourned.

FORT LEAVENWORTH, KANS., *July* 14, 1874.

The board met pursuant to adjournment. Present, all the members.

The cartridge-box of Lieutenant McKeever was received and presented to the board.

A recess was taken by the board for an hour, to remove to the new place of meeting, the Quartermaster's Department needing the building occupied, for storage purposes.

Resumed the examination of reports from officers on the new ordnance-equipments.

At 3.30 p. m. the board adjourned to meet to-morrow at 10 a. m.

FORT LEAVENWORTH, KANS., *July* 15, 1874.

The board met pursuant to adjournment. Present, all the members.

Resumed the examination of reports from officers on the new ordnance-equipments.

A communication was received from Lieut. James Regan, Ninth Infantry, forwarding plans and specifications for a new cartridge-belt. Filed, and a letter addressed to Lieutenant Regan, requesting him to forward a sample of his belt.

There being no facilities at Fort Leavenworth for constructing and remodeling equipments, the board resolved to send the following telegram to the Adjutant General of the Army:

"No facilities here for construction or elaborating plans. Board respectfully requests authority to change its place of meeting to Watervliet Arsenal, New York."

The board, having no further business before it, adjourned to meet to-morrow at 10 a. m.

FORT LEAVENWORTH, KANS., *July* 16, 1874.

The board met pursuant to adjournment. Present, all the members.

After examining documents and papers, the board, at 3.30, adjourned to meet to-morrow at 10 a. m.

FORT LEAVENWORTH, KANS., *July* 17, 1874.

The board met pursuant to adjournment. Present, all the members.

A communication was received from the Chief of Ordnance, forwarding a cartridge-box of Lieutenant Reilly, Ordnance Department. Also, a box of cartridge-boxes from Capt. Clifton Comly, San Antonio Arsenal. All submitted to the board. A locker, prepared under the direction of Lieutenant-Colonel McCook, was presented to the board and examined.

At 3 p. m. the board adjourned to meet to-morrow at 10 a. m.

FORT LEAVENWORTH, KANS., *July* 18, 1874.

The board met pursuant to adjournment. Present, all the members.

A telegram was received and submitted to the board from Maj. Thomas M. Vincent, Assistant Adjutant General, as follows:

"Secretary of War approves request for adjournment of board to meet at Watervliet Arsenal."

The following resolution was then adopted by the board:

With the approval of the Secretary of War, and awaiting the receipt of information from the commanding officers of artillery and infantry regiments, called for in circular addressed to them by the board July 9, 1874, the board resolved to adjourn to meet again at Watervliet Arsenal, New York, August 19 proximo.

There being no further business before it, the board adjourned to meet as above.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
August 19, 1874.

The board met pursuant to adjournment. Present, all the members.

Communications were received from the commanding officers of the Fourth, Eleventh, Sixteenth, Seventeenth, Nineteenth, Twentieth, Twenty-first, and Twenty-fifth Infantry; which were submitted to the board, and ordered to be filed.

Also, one from the Adjutant General's Office, in reply to communication from the president of the board of July 10. Also, another from the same source, dated July 25, referring to clerk.

Also, communication from the Chief of Ordnance, forwarding reports from the field on new infantry-equipments.

Also, special reports on experimental cartridge-boxes, from Capt. Theo. Schwan, Eleventh Infantry, commanding Company G.

Also, letter from Lieutenant Metcalfe, Ordnance Department, referring to his blocks.

Also, a letter from J. R. King, (formerly first sergeant Company K, Second Infantry,) forwarding a cartridge-box of his invention.

A cartridge-pouch (cavalry pattern) was received from Captain Deane, ordnance store-keeper, Watervliet Arsenal.

The board then, at 3 p. m., adjourned to meet to-morrow at 10 a. m.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
August 20, 1874.

The board met pursuant to adjournment. Present, all the members.

The board then proceeded to read the communications received from the commanding officers of the Fourth, Eleventh, Sixteenth, Seventeenth, Nineteenth, Twentieth, Twenty-first, and Twenty-fifth Infantry, and to discuss the recommendations expressed therein.

A new intrenching-tool, prepared at the Springfield Armory, was presented for the inspection of the board by Colonel Hagner, U. S. A.

The board then adjourned to meet to-morrow at 9 a. m.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
August 21, 1874.

The board met pursuant to adjournment. Present, all the members.

Some experiments were tried with a poncho, shelter-tent, and blanket, prepared under the direction of Lieutenant-Colonel McCook.

Several reports were read from company commanders regarding the new infantry-equipments.

The board then adjourned to meet to-morrow at 9 o'clock.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
August 22, 1874.

The board met pursuant to adjournment. Present, all the members.

Various experiments were tried by the board with Palmer's and Snyder's equipments and McKeever's cartridge-boxes; after which the board adjourned to meet on Monday morning at 9 o'clock.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
August 24, 1874.

The board met pursuant to adjournment. Present, all the members.

The session of the board was confined to a discussion of the knapsack question, and various experiments with the Palmer equipments; and then adjourned to meet to-morrow at 9 a. m.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
August 26, 1874.

The board met pursuant to adjournment. Present, all the members.

A letter was received from the Ordnance Department, informing the board that the report of the infantry board of the English army, of which Major-General Ayres was president, had been forwarded; also, the pattern of the equipment they recommended for adoption. Both were subsequently received and submitted to the board and discussed; after which the board adjourned to meet to-morrow at 9 a. m.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
August 27, 1874.

The board met pursuant to adjournment. Present, all the members.

A resolution was passed by the board, requesting Col. P. V. Hagner, commanding Watervliet Arsenal, to have constructed three double thimble-belts, (Hazen's, No. 2,) the loops in one to be of russet-leather, of another plain black leather, and of the third of plain black leather lined with linen.

The board then adjourned to meet to-morrow at 9 a. m.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
August 28, 1874.

The board met pursuant to adjournment. Present, all the members.

A resolution was passed by the board, requesting Col. P. V. Hagner, commanding Watervliet Arsenal, to have constucted a McKeever cartridge-box, with the following modifications: To be lined with linen, loops to which the box is attached to the belt to be higher up, (as marked,) and a small exterior pocket, properly secured, to contain a screw-driver.

The thimble-belts were received and discussed; after which the board adjourned to meet to-morrow morning at 9 o'clock.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
August 29, 1874.

The board met pursuant to adjournment. Present, all the members.

A cartridge-box was received from Private Burbank, Nineteenth Infantry, and a belt from Lieutenant Regan, Ninth Infantry, and submitted to the board.

Adjourned to meet on Monday morning at 9 o'clock.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
August 31, 1874.

The board met pursuant to adjournment. Present, all the members.

A communication was received from Col. D. L. Floyd-Jones, commanding Third Infantry; submitted to the board and ordered to be filed.

The board experimented with the Palmer yoke, the McKeever cartridge-box, and the Hazen thimble-belt; and adjourned to meet at the usual time to-morrow.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
September 1, 1874.

The board met pursuant to adjournment. Present, all the members.

A communication was received from Col. W. B. Hazen, commanding Sixth Infantry, on the subject of infantry-equipments, which was submitted to the board and ordered to be filed.

The board passed a resolution requesting Colonel Hagner, commanding Watervliet Arsenal, to have the following articles manufactured for the inspection of the board:

A thimble-belt of regulation length, to contain forty rounds of cartridges, caliber .45, and of as heavy leather as the sample furnished. Also, a similar belt to the above, the thimbles and side of belt to which they are attached lined with sized canvas, and of same leather in weight as cavalry loop; sample furnished. Also, a sample of the new ordnance-equipment, the braces to be curved on the inner line, narrow and lighter, without valise.

The board then adjourned until 9 a. m. to-morrow.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
September 2, 1874.

The board met pursuant to adjournment. Present, all the members.

The board passed a resolution requesting Colonel Hagner, commanding Watervliet Arsenal, to have made a haversack fitted with a brass buckle, and increased width of strap with metal eyelets. Also, a canteen similarly fitted.

After some further experiments with equipments, the board adjourned to meet to-morrow at the usual hour.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
September 3, 1874.

The board met pursuant to adjournment. Present, all the members except Colonel English, who was absent by reason of sickness.

The thimble-belts prepared the day before yesterday were presented, examined, and discussed. Also, the haversack and canteen, altered as requested yesterday.

The board then adjourned to meet to-morrow at the usual hour.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
September 4, 1874.

The board met pursuant to adjournment. Present, all the members except Colonel English, who was absent on account of sickness.

The board, after experimenting with the ordnance brace-yoke, adjourned to meet to-morrow at 9 a. m.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
September 5, 1874.

The board met pursuant to adjournment.

Present, Colonel Shafter, Major Chambers, and Captain Stacey.

Absent, Lieutenant-Colonel McCook, by permission of the board, and Lieutenant-Colonel English, sick.

The board having no special business before it, adjourned to meet on Monday, September 7, at 9 o'clock.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
September 7, 1874.

The board met pursuant to adjournment.

Present, Colonel Shafter, Major Chambers, and Captain Stacey.

Absent, Colonel McCook, by permission of the board, and Colonel English, sick.

After making some experiments with equipments, the board adjourned to meet to-morrow at 9 a. m.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
September 8, 1874.

The board met pursuant to adjournment. Present, all the members except Lieutenant-Colonel English, sick.

The session of the board was devoted to experiments with infantry-equipments, after which it adjourned to meet to-morrow at the usual hour.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
September 9, 1874.

The board met pursuant to adjournment. Present, all the members except Lieutenant-Colonel English, sick.

A telegram was received from Lieut. George H. Palmer, Sixteenth Infantry, informing the board that he had shipped by express an improved set of his equipments.

After reading some reports from various officers in the field, the board adjourned to meet again to-morrow at the usual hour.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
September 10, 1874.

The board met pursuant to adjournment. Present, all the members except Lieutenant-Colonel English, sick.

The board unanimously resolved to apply to the Adjutant General of the Army for an order to have Lieut. George H. Palmer, Sixteenth

Infantry, report to the board, to explain the merits of the brace-yoke and equipments invented by him. A letter was accordingly written to that effect.

Lieutenant Metcalfe, Ordnance Department, U. S. A., came before the board to exhibit his improved cartridge-block and attachment, which was discussed, and Lieutenant Metcalfe invited to appear before the board to-morrow and give a test of its merits.

The board then adjourned to meet at the usual time to-morrow.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
September 11, 1874.

The board met pursuant to adjournment. Present, all the members.

The board and Lieutenant Metcalfe, Ordnance Department, experimented as to rapidity of fire with his cartridge-block and attachment. For further experiment it was resolved by the board to request the Chief of Ordnance to instruct the commanding officer of Springfield Armory to have prepared—

Two Springfield rifles, caliber .45, with Metcalfe's cartridge-block-strap attachment.

Two Springfield rifles, caliber .45, with key attachment.

Also, 1,000 of Lieutenant Metcalfe's cartridge-blocks, caliber .45, holding 8 cartridges, filled.

Also, 1,000 of Lieutenant Metcalfe's cartridge-blocks, caliber .45, holding 10 cartridges, filled. Also, two cartridge-boxes for each gun.

The board then adjourned to meet at the usual hour to-morrow.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
September 12, 1874.

The board met pursuant to adjournment. Present, all the members.

A letter was received from Lieutenant Palmer, stating that he had shipped an improved set of his equipments.

Pending their arrival, the board adjourned to meet Monday morning, September 14, at 9 oclock.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
September 14, 1874.

The board met pursuant to adjournment. Present, all the members.

A letter was received from J. D. Vermuele, vice-president Goodyear's India-Rubber Glove Manufacturing Company, addressed to the commanding officer Watervliet Arsenal, asking information of how he could submit an infantry-equipment to the board. The recorder was directed to inform him, and invite him to submit a sample of his equipment without delay.

The board then proceeded to discuss the subject of a canteen-strap, and passed a resolution requesting the commanding officer Watervliet Arsenal to have prepared a canteen-strap six inches longer and one-third wider than in the sample furnished, of the same material, to fasten with a small box-buckle, eyelets to be placed in the strap for about one foot, and to be made twice as wide in the flange. Also, a buckle as above with clamp tongue, strap without eyelets, and of white webbing.

The board then adjourned to meet again to-morrow at the usual hour.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
September 15, 1874.

The board met pursuant to adjournment. Present, all the members.

Two sets of infantry-equipments were received from First Lieut. George H. Palmer, Sixteenth Infantry, and submitted to the board.

Also, samples of the strap and buckles ordered yesterday.

The buckles were returned for some modifications.

The board then adjourned.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
September 16, 1874.

The board met pursuant to adjournment. Present, all the members.

Some experiments were made with the new equipments submitted by Lieutenant Palmer, and after some discussion of their relative merits over the first ones submitted by this officer, the board adjourned until September 18, to meet at the usual hour.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
September 18, 1874.

The board met pursuant to adjournment. Present, all the members except Lieutenant-Colonel English, sick.

A resolution of the board requesting the commanding officer Watervliet Arsenal to have made the following articles was passed:

One belt and plate, similar to the one submitted.

Two small double loops of brass wire, ⅛ inch in diameter, to be fastened into each slot of the buckle; loops to be sufficiently large to admit of hooking into a small snap-hook.

Four sets of cartridge-loops, each to contain twenty rounds of ammunition; caliber, .45. The leather for the loops should be quite as heavy as in that submitted; the outer row of loops to contain twelve rounds, and the inner eight.

This belt and plate and cartridge-loops are desired as a model to be submitted to the Chief of Ordnance if adopted by the board.

After some experiments with the Palmer brace-yoke, the board adjourned to meet to-morrow at 9 a. m.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
September 19, 1874.

The board met pursuant to adjournment. Present, all the members.

A letter was received from the Adjutant General United States Army, stating that Lieut. G. H. Palmer, Sixteenth Infantry, being *en route* to New Orleans with his company, could not be ordered to report to the board. Mr. M. V. B. White came before the board, and exhibited a specimen of a cartridge-box invented by him, which was experimented with. The inventor took his box away to make some improvements.

The board then adjourned to meet on Monday at 9 a. m.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
September 21, 1874.

The board met pursuant to adjournment. Present, all the members except Lieutenant-Colonel McCook, absent by permission of the board.

After some experiments with cartridge-boxes, the board adjourned until to-morrow at the usual time.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
September 22, 1874.

The board met pursuant to adjournment. Present, all the members.

Mr. Sherlock came before the board and exhibited an infantry-equipment, in reference to which the board has corresponded with Mr. Vermuele.

Mr. White was also before the board with his cartridge-box, and some experiments were tried with it for rapidity of fire, which were not satisfactory.

The board then adjourned to meet at the usual time to-morrow.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
September 23, 1874.

The board met pursuant to adjournment. Present, all the members.

The session of the board was devoted to experiments with infantry-equipments.

The commanding officer Watervliet Arsenal was requested to make some changes in the canteen and haversack straps.

The board then adjourned to meet at the usual time to-morrow.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
September 24, 1874.

The board met pursuant to adjournment. Present, all the members except Colonel English, sick.

The session of the board was devoted to experiments with infantry-equipments, and then adjourned to meet at the usual time to-morrow.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
September 25, 1874.

The board met pursuant to adjourment. Present, all the members.

Experiments with infantry-equipments continued.

A communication was received from Col. Kilburn Knox, asking information how to present a shelter-tent and knapsack for the inspection of the board. Replied to, giving the required information.

The board then adjourned to meet at usual time to-morrow.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
September 26, 1874.

The board met pursuant to adjournment.

Present, Lieutenant-Colonel Shafter, Lieutenant-Colonel McCook, and Captain Stacey.

Absent, Lieutenant-Colonel English, by permission of the board, and Major Chambers, sick.

The board experimented with infantry-equipments, and then adjourned until Monday, September 28, 1874, at 9 o'clock.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
September 28, 1874.

The board met pursuant to adjournment. Present, all the members except Lieutenant-Colonel English, absent by permission of the board.

By a resolution of the board, the commanding officer of Watervliet

Arsenal was requested to have prepared for the inspection of the board a circular canvas water-proof sack of the following dimensions:

Length, 25 inches; circumference, 30 inches. The lower head of the bag to be circular in shape, and sewed in on each side; two straps, 3 inches long, to be sewed with buckles for the steady-straps. Two other similar straps, 4 inches apart, near the inside center, into which the straps from the back-pad will buckle. The top end of the sack to work on a leather hinge, with a strap and buckle to hold it in place. In addition, to have three loops, one on each side and one directly in rear, through which the top or upper strap will pass to hold the sack in its place.

After further experiments, the board adjourned to meet at the usual time to-morrow.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
September 29, 1874.

The board met pursuant to adjournment. Present, all the members.

Experimented with infantry equipments, and then adjourned.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
September 30, 1874.

The board met pursuant to adjournment. Present, all the members except Lieutenant-Colonel McCook, absent by permission of the board.

Some experiments were tried with the Palmer brace-yoke, improved by the board, and also with the sack ordered the day before yesterday.

Adjourned to meet at the usual hour to-morrow.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
October 1, 1874.

The board met pursuant to adjournment.

Present, Lieutenant-Colonel Shafter and Captain Stacey.

Absent, Lieutenant-Colonel McCook, by permission of the board; Lieutenant-Colonel English and Major Chambers, sick.

There being no quorum, the board adjourned.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
October 2, 1874.

The board met pursuant to adjournment.

Present, Lieutenant-Colonel Shafter, Major Chambers, and Captain Stacey.

Absent, by permission of the board: Lieutenant-Colonel McCook and Lieutenant-Colonel English.

A sample knapsack was received from Sergt. Patrick Boland, Company C, Nineteenth Infantry, and submitted to the board.

After discussing it, the board adjourned to meet at the usual hour to-morrow.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
October 3, 1874.

The board met pursuant to adjournment. Present, all the members except Lieutenant-Colonel McCook, absent by permission of the board.

Adjourned to meet on Monday, October 5, at the usual hour.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
October 5, 1874.

The board met pursuant to adjournment. Present, all the members except Lieutenant-Colonel McCook, absent by permission of the board.

There being no business before it, the board adjourned to meet at the usual hour to-morrow.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
October 6, 1874.

The board met pursuant to adjournment. Present, all the members except Lieutenant-Colonel McCook, absent by permission of the board.

Some experiments were tried with the haversack, and the board adjourned.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
October 7, 1874.

The board met pursuant to adjournment. Present, all the members.

The board discussed the knapsack question, and adjourned to meet at the usual hour to-morrow.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
October 8, 1874.

The board met pursuant to adjournment. Present, all the members.

Experiments were made with a new buckle for the haversack and canteen straps, suggested by Major Chambers.

Colonel McCook submitted samples of knife, fork, and spoon that should be furnished the soldier for field-service.

The board then adjourned to meet at the usual hour to-morrow.

WATERVLIET ARSENAL, WEST TROY N. Y.,
October 9, 1874.

The board met pursuant to adjournment. Present, all the members.

Mr. A. W. Sus (29 Broadway, N. Y., room 13, P. O. box 1116) came before the board and presented a knapsack of his invention, and exhibited the merits claimed for it. It was discussed, and tried in various ways.

The board then adjourned to meet at the usual hour to-morrow.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
October 10, 1874.

The board met pursuant to adjournment. Present, all the members.

The subject of the haversack was discussed, and, pending the construction of a haversack on a plan suggested by Colonel Shafter, the board adjourned to meet at the usual hour on Monday, the 12th.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
October 12, 1874.

The board met pursuant to adjournment.

Present: Lieutenant-Colonel Shafter, Major Chambers, and Captain Stacey.

Absent: Lieutenant-Colonel McCook and Lieutenant-Colonel English.

The articles ordered on Saturday not being ready for the inspection of the board, it adjourned until to-morrow at the usual hour.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
October 13, 1874.

The board met pursuant to adjournment. Present, all the members except Lieutenant-Colonel Shafter, absent by permission of the board.

Lieut. C. C. MacConnell, Fifth Artillery, came before the board and presented a cartridge-box of his invention, and gave an illustration of the merits claimed for it.

The board examined the haversack suggested by Colonel Shafter, and then adjourned to meet at the usual hour to-morrow.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
October 14, 1874.

The board met pursuant to adjournment. Present, all the members.

The subject of the haversack was discussed.

Adjourned to meet at the usual hour to-morrow.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
October 15, 1874.

The board met pursuant to adjournment. Present, all the members.

A communication was received from Hermann Boker & Co., stating that they intended to present samples of knives, forks, and spoons. Filed.

Adjourned to meet at the usual hour to-morrow.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
October 16, 1874.

The board met pursuant to adjournment. Present, all the members.

A communication was received from Russell Manufacturing Company, in reference to knives, forks, and spoons. Filed.

A letter was written to James W. Schaumburg, Philadelphia, inviting him to present his infantry-equipments for the inspection of the Board.

Adjourned to meet at the usual hour to-morrow.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
October 17, 1874.

The board met pursuant to adjournment. Present, all the members.

Mr. Johnson, representing Hermann Boker & Co., of New York, came before the board with samples of knives, forks, and spoons, which were discussed.

The board adjourned to meet on Monday, October 19, at the usual hour.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
October 19, 1874.

The board met pursuant to adjournment. Present, all the members.

The discussion of infantry-equipments was continued.

Board adjourned to meet at the usual hour to-morrow.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
October 20, 1874.

The board met pursuant to adjournment. Present, all the members except Lieutenant-Colonel McCook, absent by permission of the board.

Mr. Johnson, of Hermann Boker & Co., was before the board with samples of knives, forks, and spoons.

Adjourned to meet at the usual hour to-morrow.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
October 21, 1874.

The board met pursuant to adjournment. Present, all the members except Lieutenant-Colonel McCook, absent by permission of the board.

Samples of knives, forks, and spoons were received from the Meriden Cutlery Company, and from the John Russell Cutlery Company.

Adjourned to meet to-morrow at the usual hour.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
October 22, 1874.

The board met at the usual hour, pursuant to adjournment. Present, all the members.

Pending the completion of certain work ordered in the shops, the board adjourned to meet to morrow at the usual hour.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
October 23, 1874.

The board met pursuant to adjournment. Present, all the members.

Lieut. Henry Metcalfe, Ordnance Department, came before the board and presented his improved cartridge-blocks and attachment.

James W. Schaumburg sent his cartridge-supporters to the board, all of which were submitted.

A letter was addressed to the Chief of Ordnance, requesting that the further construction of Lieutenant Metcalfe's cartridge-blocks, holding ten cartridges, might be discontinued, as those holding eight cartridges are thought to possess greater merit.

The board then adjourned.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
October 24, 1874.

The board met pursuant to adjournment. Present, all the members.

The board experimented with Lieutenant Metcalfe's cartridge-blocks and holders, and then adjourned to meet on Monday at 9 a. m.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
October 26, 1874.

The board met pursuant to adjournment. Present, all the members except Captain Stacey, absent by permission of the board.

The discussion of infantry-equipments was continued.

Adjourned to meet at the usual time to-morrow.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
October 27, 1874.

The board met pursuant to adjournment. Present, all the members except Colonel Shafter and Captain Stacey, absent by permission of the board.

The discussion of infantry-equipments was continued.

Adjourned to meet at the usual time to-morrow.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
October 28, 1874.

The board met pursuant to adjournment. Present, all the members.

The discussion of infantry-equipments was continued.

Adjourned to meet at the usual time to-morrow.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
October 29, 1874.

The board met pursuant to adjournment. Present, all the members.

The discussion of infantry-equipments was continued.

Cutlery received from J. Russell Cutlery Company, Turner's Falls, Mass., and Charles Parker, Meriden, Conn., was returned, by order of the board.

Adjourned to meet at the usual time to-morrow.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
October 30, 1874.

The board met pursuant to adjournment. Present, all the members.

The discussion of infantry-equipments was continued.

Adjourned to meet at usual time to-morrow.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
October 31, 1874.

The board met pursuant to adjournment. Present, all the members.

The discussion of infantry-equipments was continued.

Board adjourned to meet Monday, November 2.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
November 2, 1874.

The board met pursuant to adjournment. Present, all the members except Lieutenant-Colonel English, absent by permission of the board.

The discussion of infantry-equipments was continued.

Board adjourned to meet to-morrow at the usual time.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
November 3, 1874.

The board met pursuant to adjournment. Present, all the members except Lieutenant-Colonel Shafter and Lieutenant-Colonel English, absent by permission of the board.

The discussion of infantry-equipments was continued.

The board adjourned to meet at the usual time to-morrow.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
November 4, 1874.

The board met pursuant to adjournment. Present, all the members except Captain Stacey, sick.

The discussion of infantry-equipments was continued.

Adjourned to meet at the usual time to-morrow.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
November 5, 1874.

The board met pursuant to adjournment. Present, all the members.

Mr. Sherlock came before the board and presented another sample of his knapsack and appendages, which was experimented with by the members of the board.

Mr. J. D. Vermuele was also before the board, and was requested to furnish sample of India-rubber poncho.

Board adjourned to meet to-morrow at the usual time.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
November 6, 1874.

The board met pursuant to adjournment. Present, all the members.

The discussion of infantry-equipments was continued and various experiments tried, after which the board adjourned to meet at the usual hour to-morrow.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
November 7, 1874.

The board met pursuant to adjournment. Present, all the members.

The discussion of infantry-equipments was continued.

The board then adjourned to meet on Monday, November 9, at the usual hour.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
November 9, 1874.

The board met pursuant to adjournment. Present, all the members.

Mr. Waters, builder of paper boats, came before the board and presented a sample knapsack, which was submitted and discussed.

The board adjourned to meet again to-morrow.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
November 10, 1874.

The board met pursuant to adjournment. Present, all the members.

The board then proceeded to vote that the following be recommended for adoption as the proper equipment of an infantry-soldier:

1. Waist-belt and plate of a pattern submitted by Col. P. V. Hagner, commanding Watervliet Arsenal.
2. The bayonet-scabbard as now furnished except when trowel-bayonet is carried, when the bayonet-scabbard shall be of the pattern manufactured by the Ordnance Department.
3. The cartridge-box invented by First Lieut. Samuel McKeever, Second Infantry, as modified and improved by the board.
4. The canteen submitted by the Ordnance Department, with the improvements in strap and buckle made by the board.
5. The haversack with adjustable strap, manufactured under directions of the board, containing knife, fork, spoon, meat-can and plate combined, and tin cup; to be worn either over the right shoulder or attached to the brace-yoke.
6. The Palmer brace-yoke. Pending discussion on this the board adjourned to meet at the usual hour to-morrow.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
November 11, 1874.

The board met pursuant to adjournment. Present, all the members except Lieutenant-Colonel Shafter, absent by permission of the board.

Pending the completion of some work, ordered in the shops, the board adjourned to meet at the usual hour to-morrow.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
November 12, 1874.

The board met pursuant to adjournment. Present, all the members except Lieutenant-Colonel Shafter, absent by permission of the board.

The Palmer brace-yoke and appendages were adopted as a part of the infantry-soldier's equipment.

Adjourned till to-morrow at the usual hour.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
November 13, 1874.

The board met pursuant to adjournment. Present, all the members except Lieutenant-Colonels Shafter and McCook, absent by permission of the board.

The commanding officer of Watervliet Arsenal was requested to have manufactured a Palmer brace-yoke and appendages as modified by the board.

Adjourned to meet at the usual time to-morrow.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
November 14, 1874.

The board met pursuant to adjournment. Present, all the members except Lieutenant-Colonel Shafter, absent by permission of the board, and Lieutenant-Colonel English, sick.

Pending completion of work in shops, the board adjourned to meet on Monday, November 16, at the usual hour.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
November 16, 1874.

The board met pursuant to adjournment. Present, all the members.

The subject of swords for company-sergeants was discussed, and the board decided to recommend that they be no longer carried.

It was also decided that Capt. J. W. Piper's trowel-bayonet scabbard is not suitable for adoption in the military service.

Adjourned to meet at the usual time to-morrow.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
November 17, 1874.

The board met pursuant to adjournment. Present, all the members except Lieutenant-Colonel English, sick.

A request was made to the commanding officer of Watervliet Arsenal to have a model locker made, of the following dimensions: 10 by 10 by 22; strap-hinges for lid; chest-lock; made of pine or white-wood.

The board decided to recommend that a box of cleaning-material, similar to the sample furnished from the National Armory, Springfield, be supplied to each company, with the following modifications:

2 quart cans of anti-corrosive and lubricating oil.
1 box (holding forty ounces) scouring-material, marked I.
1 box (containing sixteen ounces) polishing-material for leather, marked II.
1 box (holding forty ounces) whiting.
1 chamois-skin, about 2 feet square.
1 wire scratch-brush.

The board then adjourned to meet at the usual hour to-morrow.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
November 18, 1874.

The board met pursuant to adjournment. Present, all the members except Lieutenant-Colonel English, sick.

The model of the equipments having been completed, application was made to Col. P. V. Hagner, commanding Watervliet Arsenal, to detail Lieut. John Pitman, Ordnance Department, to photograph them.

Adjourned to meet at the usual hour to-morrow.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
November 19, 1874.

The board met pursuant to adjournment. Present, all the members except Lieutenant-Colonel English, sick.

Lieutenant Pitman engaged photographing models.

Adjourned to meet at the usual time to-morrow.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
November 20, 1874.

The board met pursuant to adjournment. Present, all the members except Lieutenant-Colonel English, sick.

A telegram was received from the Chief of Ordnance, requesting the board not to adjourn *sine die* until hearing from his Office, as other mattres might be referred to it.

While the final report is being prepared, the board adjourned to meet at the usual hour to-morrow.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
November 21, 1874.

The board met pursuant to adjournment. Present, all the members except Lieutenant-Colonel English and Major Chambers, sick.

There being no business before the board ready for its action, adjourned to meet on Monday morning, November 23, at the usual hour.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
November 23, 1874.

The board met pursuant to adjournment. Present, all the members except Lieutenant-Colonel English, sick.

A communication was received from the Chief of Ordnance, requesting information as to whether it was necessary for Capt. J. W. Piper, Fifth Artillery, to appear before the board to explain the merits of his trowel-scabbard. The board directed that it be respectfully returned, with the following indorsement:

Respectfully returned.

The following is an extract from the proceedings of the board in regard to the trowel-scabbard of Capt. J. W. Piper, Fifth Artillery:

"Not regarded as suitable for adoption in the military service." It will not, therefore, be necessary for Captain Piper to appear before the board.

A communication was received from the Chief of Ordnance in reference to the desirability of providing, for the infantry-arm of the service, a cart similar to the one recommended for the cavalry. Pending discussion on this subject, the board adjourned to meet to-morrow at the usual hour.

WATERVLIET ARSENAL, WEST TROY, N, Y.,
November 24, 1874.

The board met pursuant to adjournment.

Present, Lieutenant-Colonel Schafter, Lieutenant McCook, and Captain Stacey.

The following letter was addressed to the Chief of Ordnance:

"Your communication of the 21st has been received and submitted to the board on infantry-equipments. The subject of an infantry-cart has been considered and frequently discussed, but the board are of the opinion that, while at times such a vehicle might be useful, there are so many objections that can be urged against it that they do not recommend its introduction."

The following letter was also addressed to the Adjutant General, United States Army:

"The board on infantry-equipments, convened by paragraph 14, Special Orders 120, from your Office, dated Washington, June 1, 1874, having completed the duty assigned it, in accordance with a telegram from the Chief of Ordnance, dated November 20, 1874, await further instructions."

After signing a fair copy of the report to the Chief of Ordnance, the board adjourned to meet at the call of the president.

M. H. STACEY,
Captain Twelfth Infantry, Bvt. Lieut. Col., U. S. A.,
Recorder of the Board.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
December 2, 1874.

The board on infantry-equipments met at the call of the president.

Present, Lieutenant-Colonel Shafter and Captain Stacey.

The following order was submitted:

[Special Orders No. 258.—Extract.]

WAR DEPARTMENT, ADJUTANT GENERAL'S OFFICE,
Washington, November 16, 1874.

1. The board on infantry-equipments, &c., appointed by paragraph 14, Special Orders No. 120, June 1, 1874, from this Office, and now in session at Watervliet arsenal, N. Y., having completed its duties, is dissolved.

The officers composing the board, except the recorder, will join their proper stations.

By order of the Secretary of War:

E. D. TOWNSEND,
Adjutant General.

In accordance with the above orders the board adjourned *sine die.*

W. R. SHAFTER,
Lieut. Col. Twenty-fourth Infantry, President of the Board.

M. H. STACEY,
Captain Twelfth Infantry, Bvt. Lieut. Col., U. S. A., Recorder.

Letters and communications received by the board on infantry-equipments, convened by Special Orders No. 120, from Adjutant General's Office, Washington, D. C., dated June 1, 1874.

File reference.	Date of receipt.	Writer's name.	Subject.
	1874.		
No. 1	July 1	Lieut. George H. Palmer, Sixteenth Infantry.	Improved infantry-equipments.
No. 2	July 2	Capt. J. A. Snyder, Third Infantry	Do.
No. 3	July 2	do	Report on experimental cartridge-boxes.
No. 4	July 2	Conrad Blattner	Soldiers' cleaning-kit.
No. 5	July 6	do	Improved soldier's kit, with model.
No. 6	July 6	Lieut. H. H. Hubbell, First Artillery	Report on infantry-equipments.
No. 7	July 6	Acting Chief of Ordnance	Gives list of company commanders ordered to make special reports to board on cartridge-boxes.
No. 8	July 6	A. D. Laidley	Forwards new cartridge-box.
No. 9	July 6	Capt. J. Ford Kent, Third Infantry	Reports on cartridge-boxes.
No. 10	July 6	First Lieut. James Regan, Ninth Infantry.	Report on cartridge-box.
No. 11	July 6	D. W. C. Baxter	Forwards knapsack-supporter.
No. 12	July 6	Capt. C. Comly, Ordnance Department.	Forwards invoices and receipts for ordnance-stores shipped.
No. 13	July 6	Capt. Thomas M. Deane, ordnance store-keeper.	Forwards invoice of ordnance-stores from Watervliet Arsenal.
No. 14	July 8	Col. G. Pennypacker, Sixteenth Infantry.	Introduces to board Lieutenant Palmer.

Letters and communications received by the board on infantry-equipments, &c.—Continued.

File reference.	Date of receipt.	Writer's name.	Subject.
No. 15	1874. July 9	Capt. B. F. Rittenhouse, Fifth Artillery.	Forwards cartridge-box.
No. 16	July 11	Stuart & McCair, quartermaster's agents.	Inclosing bill of lading, ordnance-stores.
No. 17	July 11	Lieut. William Raphall, Eleventh Infantry.	Forwards invoice of ordnance-stores.
No. 18	July 13	General S. V. Benét, Chief of Ordnance.	Notifies board that a cartridge-box from Lieutenant McKeever has been forwarded.
No. 19	July 14	Capt. R. Nugent, Thirteenth Infantry.	Reports upon cartridge-boxes.
No. 20	July 15	First Lieut. James Regan, Ninth Infantry.	Forwards drawing for cartridge-box.
No. 21	July 16	First Lieut. G. W. Baird, adjutant Fifth Infantry.	Forwards plans for improvement of quarters.
No. 22	July 16	First Lieut. Henry Romeyn, Fifth Infantry.	Referring to common and shelter tents.
No. 23	July 17	General S. V. Benét, Chief of Ordnance.	(Private.) Explaining object of board.
No. 24	July 17	......do	Refers letter of Lieutenant Reilly in reference to his cartridge-box.
No. 25	July 18	Capt. H. E. Stansbury, Nineteenth Infantry.	Transmits cartridge-box invented by Private Burbank.
No. 26	July 18	Maj. T. M. Vincent, assistant adjutant general.	Telegram for board to adjourn to Watervliet arsenal.
No. 27	Aug. 19	......do	Refers to clerk.
No. 28	Aug. 19	......do	Defines extent and meaning of paragraph 14, Special Orders 120, War Department.
No. 29	Aug. 19	Lieut. Henry Metcalfe, Ordnance Department.	Inclosing report from Capt. J. C. Gilmore, Twenty-fourth Infantry, on cartridge-blocks.
No. 30	Aug. 19	Capt. Thomas M. Deane, ordnance store-keeper.	Forwards invoice of cartridge-pouch.
No. 31	Aug. 19	T. M. Vincent, assistant adjutant general.	Defines extent and meaning of paragraph 14, Special Orders 120, War Department, (copy.)
No. 32	Aug. 19	Capt. J. W. Clous, Twenty-fourth Infantry.	Reports on cartridge-box.
No. 33	Aug. 19	Capt. R. A. Torrey, Thirteenth Infantry.	Do.
No. 34	Aug. 19	First Lieut. James Regan, Ninth Infantry.	Forwards model.
No. 35	Aug. 19	Lieut. George H. Palmer, Sixteenth Infantry.	Forwards two sets of infantry-equipments.
No. 36	Aug. 19	Capt. L. Lorain, Third Artillery	In reply to letter of July 13, referring to infantry-equipments.
No. 37	Aug. 19	Capt. Theodore Schwan, Eleventh Infantry.	Reports on cartridge-boxes.
No. 38	Aug. 26	Capt. Henry M. Smith, Twenty-first Infantry.	Do.
No. 39	Aug. 26	Lieut. George W. McKee, Ordnance Department.	Forwards General Ayres's report, and sends sample by express.
No. 40	Aug. 26	Lieut. G. W. McKee, Ordnance Department.	Forwards reports from the field.
No. 41	Aug. 26	E. D. Townsend, Adjutant General.	Grants authority to transport the knapsack of Corporal Boland, Nineteenth Infantry.
No. 42	Sept. 8	Lieut. F. L. Dodge, Twenty-third Infantry.	Reports trial of cartridge-boxes.
No. 43	Sept. 15	Lieut. George H. Palmer, Sixteenth Infantry.	Forwards infantry-equipments.
No. 44	Sept. 15	......do	Do.
No. 45	Sept. 18	Capt. R. C. Parker, Twelfth Infantry	Details Private John Pfeiffer as clerk for the board.
No. 46	Sept. 19	General E. D. Townsend, Adjutant General.	States that Lieutenant Palmer cannot be spared, being *en route* to New Orleans with his company.
No. 47	Sept. 25	Kilbourn Knox	Asking information as to how he can present a knapsack and shelter-tent combined.
No. 48	Oct. 2	Sergt. P. Boland, Company C, Nineteenth Infantry.	Submits sample of knapsack.
No. 49	Oct. 10	Lieut. C. C. MacConnell, Fifth Artillery.	States his intention to appear before the board to present a cartridge-box of his invention.
No. 50	Oct. 15	Hermann Boker & Co	Will present samples of knives, forks, and spoons.

Letters and communications received by the board on infantry-equipments, &c.—Continued.

File reference.	Date of receipt.	Writer's name.	Subject.
	1874.		
No. 51......	Oct. 15	James W. Schaumburg, No. 272 South Fourth street, Philadelphia.	Infantry-equipments.
No. 52......	Oct. 16	Russell Manufacturing Company....	Knives, forks, and spoons.
No. 53......	Oct. 23	General Rufus Ingalls, assistant quartermaster general.	Acknowledges receipt of request of board for blanket and shelter-tent, and states that letter has been referred to Colonel Easton, assistant quartermaster general, Philadelphia.
No. 54......	Oct. 28	Col. P. V. Hagner, Ordnance Department.	Refers letter of G. K. Sheridan, referring to cotton duck.
No. 55......	Oct. 29	......do	Do.
No. 56......	Oct. 30	General S. V. Benét, Chief of Ordnance.	Refers letter of Capt. James W. Piper in reference to trowel-bayonet.
No. 57......	Oct. 30	Hermann Boker & Co...............	Sending samples of cutlery.
No. 58......	Nov. 2	Col. L. C. Easton, assistant quartermaster general.	In reference to Army blanket and shelter-tent.
No. 59......	Nov. 3	C. S. Sanders	In reference to cutlery.
No. 60......	Nov. 6	General M. C. Meigs, Quartermaster General.	Informing board that he has given instructions to Colonel Easton to furnish blanket and shelter-tent.

NOTE.—The foregoing letters and communications are not embraced in this report. They are on file in the office of the Chief of Ordnance.

DESCRIPTION OF INFANTRY-EQUIPMENTS AND PARTS OF EQUIPMENT SUBMITTED TO A BOARD OF OFFICERS CONVENED BY PARAGRAPH 14, SPECIAL ORDERS 120, FROM THE ADJUTANT GENERAL'S OFFICE, DATED JUNE 1, 1874. PREPARED BY CAPT. M. H. STACEY, TWELFTH INFANTRY, RECORDER.

Infantry-equipments submitted by the Ordnance Department, from Watervliet Arsenal.

One set accouterments, buff-leather belts, pattern 1850, consisting of—
1 cartridge-box.
1 cap-pouch.
1 cartridge-box shoulder-belt.
1 waist-belt and plate.
1 bayonet-scabbard, leather, with frog attached.
1 gun-sling for musket; cal. .58.
1 N. C. O. sword shoulder-belt. (Double frog for sword and bayonet-scabbard and plate.)
1 N. C. O. waist-belt and plate.
1 N. C. O. sword, with leather scabbard.

Infantry-equipments submitted by the Ordnance Department, from Watervliet Arsenal.

One set of accouterments, grained-leather belts, pattern of 1861, consisting of—
1 cartridge-box.
1 cap-pouch.
1 waist-belt and plate, carrying cartridge-box and cap-pouch.
1 bayonet-scabbard, leather, with frog.
1 gun-sling.
1 N. C. O. waist-belt and plate, and frog for sword.

Description of infantry-equipments sent from Watervliet Arsenal, (pattern of 1872,) consisting of—

1 pair shoulder-braces, slide attachment.
1 cartridge-box, No. 1.
1 cartridge-box, No. 2.
1 waist-belt and plate.
1 valise.
1 scabbard, steel, Hoffman's attachment.
1 pair coat-straps.
1 pair steady straps.
1 haversack.
1 canteen, covered with petersham cloth.
1 meat-ration can, with cup-cover.
1 gun-sling, lengthened for musket, pattern 1870.
1 N. C. O. sword-frog, swivel attachment.
1 N. C. O. sword, steel scabbard, inside guard-plate reduced.

Additional experimental parts of equipment from Watervliet Arsenal, consisting of—

1 valise, black-rubber flap.
1 valise, petersham-cloth flap.
1 valise, seal-skin flap.
1 meat-ration can, 6 by 6, without cup, with hinged cover.
1 meat-ration can, 6½ by 8, with hinged cover, (proposed.)
(A) 1 enameled-cloth haversack.
(B) 1 enameled-cloth haversack, with tins.
1 knapsack, 1 haversack, 1 canteen, pattern 1860.

(C) 1 cartridge-box, cal. .58, with tins removed. Holds forty cartridges, cal. .50, in two original packages, the upper one to be emptied and then placed at bottom. Could also be fitted for cal. .45.

(D) 1 cartridge-box, cal. .58, with perforated wooden blocks for forty cartridges, cal. .50. Could be fitted for cal. .45.

1 cartridge-box, with McGinness's pattern block for forty cartridges, cal. .50. Could be fitted for cal. .45.

1 Butler box, No. 1, curved, for nineteen cartridges.
1 Butler box, No. 2, straight, for twenty cartridges.
1 Hazen's belt, No. 1, for forty cartridges.
1 Hazen's belt, No. 2, for forty cartridges.

1 Dyer pouch, with sheep-skin lining, modified cavalry board pattern, holding forty (cal. .45) cartridges.

1 box, carrying one original package of fifty (cal. .45) cartridges, to be replaced as emptied. On campaign, two boxes may be used.

Lieutenant Palmer's army-equipments, submitted by First Lieut. George H. Palmer, Sixteenth Infantry.

The infantry-equipments consist of carrying-braces, coat-straps, knapsack, and haversack, the whole weighing three and one-half pounds. Bags or pouches, with water-proof flaps, are used for knapsack and haversack. The haversack, which is a little smaller than the knapsack, is carried on the right side, the knapsack on the left side.

The carrying-braces consist of a back-pad and double shoulder-straps —two straps for each shoulder.

The shoulder-straps are attached to the back-pad by rivets, so as to be movable on their fastenings. The back-pad gives additional bearing-surface for the weight carried. Its shape enables the shoulder-straps to be attached in such a manner as to separate them on the back and shoulders. The back-pad, in connection with the shoulder-straps, prevents the weight carried from pulling directly downward on the shoulders, instead of which it tends to pull toward the center of the back by means of the pad supporting a portion of the weight.

Two straps are attached to the front ends of each shoulder-strap, for supporting the front corners of the bags, the waist-belt, and cartridge-boxes.

To the back-pads are fastened rings which hold the blanket-straps. Two straps are attached to the pad, for supporting the rear corners of the bags. On these straps is a double loop, which may be moved down or up, for the purpose of drawing the bags together at the back, or to permit them to hang at the sides.

A strap looped at each end is on the blanket-straps and passes underneath the straps supporting the bags, for the purpose of holding the blanket more firmly in place when marching at double time. At the bottom of the bags are straps with buckles, for drawing the bags together at the back and to retain them more firmly in place.

The equipment is put on by holding the shoulder-straps in the hands, the bags in front of the body, flaps to the rear, and swinging them round to the left of the back, at the same time turning them, the left arm passing under the shoulder-strap, the right hand passing over the head, and under the right-shoulder strap; the waist-belt straps are then hooked.

Accouterments submitted by Capt. J. A. Snyder, Third Infantry.

DESCRIPTION.

Snyder's shelter-knapsack is composed of—

½ a shelter-tent; 3 sections of a tent-pole, with ferrules; 1 extra section suitable for top, center, or bottom piece; 1 bag, for clothing; 4 small tent-pins; 1 guy-rope; 1 set of straps.

By combining two knapsacks a complete tent is made.

The sections of the tent-pole are secured to the canvas by leather loops, and the sections of the pole are arranged in the loops in the shape of a square, making a sort of frame on one side. The 4 pins are secured in loops, inside of the sections of the pole.

The canvas bag or valise is very similar in construction to the new valise furnished by the Ordnance Department.

The pack, thus formed, has two straps on top, to which may be secured the overcoat, blanket, or poncho. The whole is carried on the back, well up on the shoulders, by means of a broad neck-yoke, tapering down toward the waist-belt. About half way between the shoulder and waist the piece forming the neck-yoke terminates in two straps, one going to the waist-belt and the other behind under the arms, hooking by brass loops to hooks in the knapsacks. The knapsack is suspended by a ring on top to a brass hook in the neck-yoke.

Snyder's cartridge-pouches.—Made to accompany the knapsack are

Snyder's cartridge-pouches, each of which will hold about thirty rounds of Springfield-rifle ammunition, (cal. .45.)

Attached to each pouch are two leather loops, through which the waist-belt passes, and a ring by which, if desired, the weight of the cartridges can be transferred from the waist to the shoulders, by means of a light strap which accompanies the pouches.

When the knapsack is worn, this object is attained by attaching to the rings the straps of the neck-yoke. The pouches are worn in front of the body, and almost on a line with the hollow of the shoulders. In this position they are convenient for use, and partly counter-balance the weight of the knapsack upon the back.

Snyder's bayonet-scabbard attachment.—Snyder's bayonet-scabbard attachment consists in a leather loop through which the waist-belt passes, and which extends about two inches below the belt. In this extension a place containing a female screw is fastened, by means of which and a small brass screw the scabbard is attached to a loop.

American patent knapsack, submitted by A. W. Sus, New York.

"The knapsack is brought upon the soldier's shoulders in the regular manner. By this new system of strapping the weight is supported from below. In fastening the small upper strap to the first hook the knapsack becomes so firmly placed on the shoulders that it cannot be forced down and made to touch the back. By connecting the higher and larger straps with the second hook the knapsack is brought higher upon the shoulders, and a constant change in the bearings of the weight can be produced, to the great relief and comfort of the soldier.

"I further produce a combination of knapsack and shelter-tent, and thereby obtain a considerable saving in weight. The soldier, when not pitching his tent, can rest upon it on the ground. The painted part being water-proof, it shelters him from dampness and ulterior sickness, while the ends of the tent he can use for a covering and the inner pocket for his pillow. The inner pocket is to receive his wearing-apparel; the rope used for lacing is the guy-rope of the tent.

"The knapsack part is large enough to admit the folding inside of blanket, overcoat, &c., protecting them from dampness, and consequent increase in weight. The sticks for pitching the tent are added in such a way as to fold around the inner pocket, doing away with the necessity of a wooden frame.

"The whole forms a simple, neat, light, and perfect knapsack.

"I have added to the knapsack half-made water-proof, to take the place of the large India-rubber poncho, for the soldier to carry over his shoulder in a rain-storm; but it is more important to sleep upon, as the soldier is protected from the damp ground, while from above he is sheltered by the tent."

Description of a set of infantry-equipments submitted by Mr. Sherlock, of New York.

This consists of a knapsack, two haversacks, two canteens, with waist-belt and straps over the shoulder to support knapsack, &c.

Knapsack is made of rubber cloth, with light, square frame of wood to preserve its shape, 11 by 11 inches and 4 inches deep. On the sides are two little pouches containing square canteens.

Haversacks are two little sacks suspended on each side of the body under the arms, and attached to brace-yoke by hooks.

The waist-belt behind is a broad piece of leather, fitting across small of back and supporting bottom of the knapsack. The blanket is rolled and suspended to the bottom of the knapsack.

Straps to waist-belt terminate in brass hooks, adjustable to any size by means of leather keepers.

The inventor claims for this equipment—

1st. Simplicity of adjustment.

2d. Equalization of weight about the body.

3d. It dispenses with straps across the body.

4th. That it prevents pressure of straps under the arms.

5th. That it dispenses with the haversack and canteen straps across the body.

6th. The broad shield of leather behind prevents knapsack from pressing against body.

7th. That the yoke permits weight to hang plumb.

8th. Claims superiority over other devices in the mode of adjusting and regulating the hooks.

9th. Calls attention to method of carrying blanket, hinging weight low down on the back.

10th. Claims lightness and substantiability for the entire equipment.

Description of knapsack submitted by Sergeant Patrick Boland, Company C, Nineteenth Infantry.

Body of knapsack made of water-proof material; (made for largest-sized men, 14½ inches square by 4 inches deep;) sides made of sole-leather, to give necessary stiffness. Stay-straps passing entirely round the knapsack-box proper; side-straps to secure blanket when rolled. The shoulder-straps are secured by buckle on one, and hook and loops on the other. Blanket is carried rolled, and secured to three sides of knapsack; overcoat on top.

The advantages claimed for this knapsack are, that the weight carried is more equally distributed; that it is kept close to and inside the line of gravity of the carrier, and is well up and retained close to the shoulders; it is readily slung and unslung, and can be kept more neatly and closely than those in use. Knapsacks could be made of four sizes for different-sized clothing.

Description of cartridge-belt and appendages submitted by First Lieut. James Regan, Ninth Infantry.

This belt is intended to carry from thirty-five to forty cartridges, arranged so as to have five in each division. The thimbles are sewed to the belt. Between each division of five cartridges is a space of about half an inch, designed to allow the covers to project a little beyond the extreme cartridges in each division. In one of these spaces is a little oblong pocket, like a spectacle-case, for screw-driver.

In the second space, on either side of the front of the belt, is a buckle, which is riveted to the belt, and designed to fasten the cross-belts. On each side of the center division of thimbles on the back part of the belt are two other buckles, to fasten the cross-belts on behind.

To each division of five cartridges is arranged a little cover for the cartridges, to prevent them from being lost by dropping out, fastened by a small brass knob, adjusted to the center thimble of each division of cartridges.

A strap and buckle, to support bayonet-scabbard, is sewed on inside of the belt on left side. The cross-belts, similar to suspenders for trousers, attached to the waist-belt, thus taking the weight entirely from the waist. To each belt is an adjustable pad of leather, of an oval shape, fitting over the shoulders. The cross-belts are arranged to carry a blanket and a change of under-clothing.

Description of samples of cartridge-boxes referred to the board by the Chief of Ordnance for examination.

No. 6080, (1872.)—*Cartridge-box from M. Schuerin.*

Description.—Made of leather; circular in shape; wooden, perforated, circular block, working on a rivet. A flap, secured by a button on the top, gives an opening from which the cartridges may be taken from the box. It may be carried either by running the waist-belt through the loops at the sides, or by shoulder-straps. Not regarded as possessing sufficient advantages for adoption in the military service.

No. 5398, (1872.)—*Cartridge-box from Sergeant C. Mongers.*

Description.—Made of leather; circular in shape. Has an outside pocket for screw-driver; inside, a circular perforated block of cork, revolving on a pivot; the inside of the box lined with and covered by tin slide; carried on right side by straps over the shoulder. Not regarded as possessing sufficient advantages for adoption in the military service.

No. 625, (1874.)—*Two cartridge-boxes from Thompson & Son.*

Description.—Made of leather; square-shaped; reversible; to contain sixty rounds of ammunition; double flap—one large, one small; carried on waist-belt on two loops, which may be reversed by unbuttoning and turning a strap on the side. Not regarded as possessing sufficient advantages for adoption in the military service.

No. 6642, (1873.)—No. 1, *Cartridge-box from E. J. Burbank, private of Company K, Nineteenth Infantry.*

Description.—Made of leather; square shaped; double flap; wooden perforated blocks to contain each twenty rounds; places on the sides to contain tompion and screw-driver; carried on waist-belt by loops on side of box.

No. 2 very similar to above, but smaller; to hold thirty rounds; without places for tompion and screw-driver.

Neither regarded as possessing sufficient advantages for adoption in the military service.

No. 1395, (1874.)—*Three cartridge-boxes from Thompson & Sons.*

Description.—Made of leather; oblong shape; each to hold thirty rounds (cal. .45) ammunition in paper cells; flap secured by brass button at the bottom of the box; carried on waist-belt by loops at each end. Not regarded as possessing sufficient advantages for adoption in the military service.

No. 1339, (1874.)—*Two cartridge-boxes from Maj. T. J. Treadwell.*

Description.—Both made of leather; one oblong shaped, the other nearly square; to hold twenty and thirty rounds of ammunition respectively; both carried by flaps secured by a brass button at the bottom of the box; carried on waist-belt by two loops; cartridges are carried in paper cells. Not regarded as possessing sufficient advantages for adoption in the military service.

No. 4463, (1873).—*Cartridge-box to contain Lieutenant Metcalfe's cartridge-holders.*

Description.—Made of leather, nearly square, to hold thirty cartridges; flaps secured by a brass button at the bottom of the box; carried on waist-belt by loops, strengthened by a cross-strap; can be removed at will, without removing the belt. Not regarded as possessing any advantages over those now in use.

1 cartridge-box, cal. .58, (old style,) with tins removed, holds 40 cartridges; cal. .50, in two original packages; obsolete.

1 cartridge-box, cal. .58, (old style,) with perforated wooden blocks, holds 40 cartridges; cal. .50; obsolete.

1 cartridge-box, cal. .58, (old style,) McGinness's pattern block for cal. .50, holds 40 cartridges; obsolete.

1 Butler's cartridge-box, No. 1, curved wooden perforated block for 19 rounds, cal. .45; flap lined with sheep-skin; secured key; revolving on pivot; carried on waist-belt by two loops. This is considered a good box, but not regarded as possessing any advantages over those now in use.

1 Butler's cartridge-box, No. 2, is similar in construction to No. 1, with the exception that it is straight. The same remarks apply to it as to the other.

1 Dyer's pouch, modified; leather; pocket lined with wool, with flap secured by button to side of pouch; carried on waist-belt; will carry 40 cartridges, cal. .45. (Cavalry-board pattern.)

1 cartridge-box carrying an original package of 30 cartridges, cal. .45; shape, oblong; made of leather; flap buttons under box; carried on waist-belt. From ordnance department, Watervliet. Not regarded as possessing any advantages over those now in use.

1 cartridge-box from Capt. B. F. Rittenhouse, Fifth Artillery. Description: Made of leather; shape, oblong; place on side for screw-driver; will hold 30 rounds, cal. .45. Not regarded as possessing any advantages over those now in use.

Hazen's belt No. 1 is simply a black leather belt, with loops on the outside, made to carry 41 cartridges.

Hazen's belt No. 2 is a black leather belt, and upon this are fastened by leather slide two double rows of loops, containing 40 cartridges.

McKeever's cartridge-box is made of leather; square-shaped; very flat; is carried on waist-belt by two leather loops. Box opens from the top, and when opened all the cartridges are exposed and convenient for use, hanging in loops one above the other. A brass bar at the bottom, riveted, holds the two sides of the box together; the top is secured by a brass button and strap. This box holds 40 cartridges.

Laidley's revolving cartridge-box; made of leather; shape, oblong; supported by waist and shoulder belt. Box can be reversed by means of brass pivots at the end. Holds 60 cartridges, in wooden perforated blocks. Not thought to possess sufficient advantages over those now in use to justify its adoption in the military service.

Samples A, B, C, D, E, H, K, L, M, N, P, of boxes, pouches, and belt have been submitted to the board, and none of them are regarded as suitable for the military service.

Description of cartridge-box submitted by Lieut. C. C. MacConnell, Fifth Artillery.

This box is square-shaped; made of leather; lined with tin; compartments to hold 40 cartridges. There is an opening at the bottom, working by means of a spring, and by which one cartridge can be taken out at a time. The cartridges are placed in the box on top by raising a flap. The box is worn on the waist-belt. Not regarded as suitable for the military service.

Description of cartridge-holder submitted by James W. Schaumburg, of Philadelphia.

This consists of a cylindrical block, 3½ inches in diameter by 6 inches in length, perforated at both ends, to hold 36 cartridges, cal. .45. Not regarded as suitable for the military service.

Miscellaneous articles of equipment submitted to the board for examination.

Baxter's knapsack-supporter.—This consists of two pieces of ash, curved to conform to the shape of the back, fastened together at top and bottom by straps, with rings and straps to secure knapsack or blanket, carried by broad cross-straps across the shoulders and fastened to the supporter behind, and also to waist-belt. Not regarded as possessing sufficient advantages for adoption in the military service.

Box of cleaning-material from Watervliet arsenal.—It contains—

2 1-pint cans of anti-corrosive and lubricating oil, (cosmoline-oil.)
1 box, holding 10 ounces scouring-material, marked I.
1 box, holding 4 ounces polishing-material for leather, marked II.
1 box, holding 10 ounces whiting.
1 chamois-skin, about 2 feet square.
1 wire scratch-brush.

This is said to be sufficient to last a company one year.

Conrad Blattner's cleaning-kit.—This consists of—

1 cloth-brush.
1 blacking-brush.
1 shoe-scrubbing brush.
1 brass-brush.
1 button-stick.
1 compound tin box; (contents: soap and blacking.)
1 compound tin box; (contents: tripoli, heel-ball, wax.)
1 oil-flask.
1 turpentine-flask.
1 tripoli-bottle; (contents: alcohol and tripoli.)
1 compound needle-box; (contents: needles and thread.)

1 pair of scissors.
1 thimble.
1 set reserve buttons.
1 looking-glass.
1 comb.
3 sheets of emery-paper.
Cleaning-rag and leather.
Case and tin frame, containing kit.

Description of Capt. J. W. Piper's (Fifth Artillery) trowel-bayonet scabbard.

This consists of a frame-shaped piece of steel, with a hollow space down the center to contain a triangular-shaped bayonet, twelve inches in the blade. It is not regarded as suitable for adoption in the military service.

NATIONAL ARMORY, SPRINGFIELD, MASS.,
November 19, 1874.

SIR: I have the honor to present to your attention the following specifications regarding my improved cartridge block and carrier, together with the arrangement for attaching the block upon the gun.

The *cartridge-block* is a wooden block, in which it is proposed that metallic cartridges shall be put up for issue at the arsenal where they are manufactured.

The *carrier* is a metallic hook, sliding upon the belt, in which it is proposed to carry the blocks full of cartridges; and the rifle and the blocks are so arranged that, at pleasure, they can be secured together in a very convenient position for loading. It is intended that the blocks, when exhausted, shall be thrown away; but they can, if necessary, be refilled and used many times.

The block.—This consists of a wooden block, 5 inches by 1¾ inches by $\frac{11}{16}$ inch, bored on its edge with eight holes to receive the same number of rifle-cartridges, cal. .45. These holes are made cylindrical, and of slightly less diameter than the corresponding portion of the taper cartridge which they inclose. The cartridge is thus held only by the upper edge of the hole, and does not touch the wood, except for a very short distance below the mouth of the hole. Were this all the precaution taken against its being too closely held by the wood, in the event of the latter's swelling from moisture, it might still be insufficient in case of excessive wetting. To provide against such a contingency, in my last model I have run a thin saw-cut along the open edge of the block, slitting the mouths of these holes.

This device has the following advantages:

1st. It effectually removes the block from the deleterious effects of moisture, as this split makes of the block a sort of automatic spring, spreading away from the cartridges when wet, and hugging close to them when dry. Experiments show that no perceptible difference is found in the facility with which the cartridges can be removed from the block after soaking it in water over night, or for longer periods of time.

2d. In case a cartridge should stick hard in the block from any cause—such as the wearing of the bit which makes the holes, and their consequent diminution in size, or from the collection of lubricant or dirt on the outside of the cartridge—this split affords a starting-point, from which, by giving a wrench to the cartridges, the block may be split open sufficiently to allow them to be easily withdrawn. By using the proper degree of force, the block may be thus broken entirely to pieces, in case, by freezing or other cause, the cartridges should be fastened permanently in their holes.

3d. It follows, as a consequence of the above, that the cartridges may be packed in the blocks at the arsenal of fabrication so tightly that they can never, under ordinary circumstances, accidentally fall out, and yet with a moment's preparation they can be loosened for rapid removal.

4th. It makes a fastening-point for the cutting-off string, and also indirectly facilitates the boring of the block.

The bottom of the block is rounded for convenience in handling.

On one side of the block are bedded and riveted two sheet-iron plates. The foremost and larger of these is called the *recoil-plate.* It is made broad, so that, by having a large bearing against the wood in rear of it, it may not sink in when the recoil (forward) in the act of firing brings the block forcibly against the attachment on the gun. The recoil-plate is punched with two holes to reduce its weight.*

The other plate is the *cam-plate.* It is principally by means of this plate that the block is fastened to the gun by a method essentially like that employed in securing the breech-block of the Springfield rifle.

The edges of the block near these plates are hollowed out in a half-round chamfer, to avoid the unnecessary projection of the plates beyond the edge of the block.

Both plates are drilled and counter-sunk for the rivets, which are common wire nails. Midway along the inside of the block is the *carrier-mortise*, a square groove an inch wide running across the block. It is designed to steady the block when transported on the carrier.

The appurtenances of the block are the pasteboard cap, the paper label which secures the cap and indicates the contents of the package, and the string by which the label is cut preparatory to the removal of the cap. The cap is rendered water-proof by being dipped in linseed-oil and baked. The string is fastened at one end of the block, and, running around the row of cartridges, has its loose end projecting in a convenient position for grasping. When filled and capped, the upper portion of the block down to the lower edge of the label is coated over with a mixture of linseed-oil and varnish, colored with burnt umber. This protects it from wet, additionally, so as to prevent a long-continued rain from soaking the attachments of the cap. If this could happen the cap might become detached and possibly allow some of the cartridges it covered to be lost. But if these were put up tightly, as before described, it will be seen that even without this water-proofing the accident would be very unlikely. As it is, however, I am able to state that two blocks so prepared were arranged on a rack under a constant stream of water from a faucet, the force of which was distributed by being received on a wad of cotton-waste overlying the blocks. They were thus in a constant soak for twenty hours without suffering at all.

The block and parts are colored brown, to harmonize with the stock and to avoid showing a decided waist-line when worn in action.

The free end of the string is glued to the side of the block by the varnish, so that it can be easily rolled off, when necessary, with the thumb.

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* Experiments made this day indicate that, provided the block is to be used for but eight shots, which is the theory of its construction, the width of the recoil-plate can be reduced to $\frac{7}{8}$ inch; in which case the tightening-holes could be dispensed with.

Materials.—Block, of bass-wood or white-wood; plates, of the cheapest sheet-iron, (No. 16 gauge;) rivets, iron-wire nails, known as "French nails;" cap, good pasteboard or strawboard; label, of rope-manila paper, printed across the grain; string, strong, tough linen string.

The gun.—The attachment on the gun is as follows:

A light iron strap sunk into the wood is connected at its rear end with the lock-plate, and consequently by the bearing of the latter against the receiver with the barrel. A tongue at its forward end passes under the lower band, by which it is kept in place.

At its forward end is formed the recoil-head, a circular undercut in which receives and matches the circular forward end of the recoil-plate.

At the proper distance in rear of this is the *cam*, which is essentially a piece of round wire, flattened on one side, and passing through the strap and riveted on the inside of it.

On the outer end of this cam is the thumb-piece, made so as to spring in and out of a slight indentation in the strap, in which it is held when in place by a slight projection on its inner surface. This flat place on the cam is parallel to the general direction of the thumb-piece, so that when the gun is horizontal and the cam open the flat place is vertical, and just far enough from the bottom of the undercut in the recoil-head to allow the passage of the shoulder of the recoil-plate on the block. It is so placed, however, as to prevent the passage of the nib.

When the cam is shut—that is, when the thumb-piece is turned parallel to the barrel—the round projecting part of the cam has entered the cam-recess. This keeps the rear end of the block from moving up or down. Its lateral motion is prevented by a lip, formed by the projection of the thumb-piece over the cam. The forward end of the block is kept in place by the projecting form of the recoil-plate, which enters the recess of the recoil-head. The block is thus securely and rigidly fastened to the strap, and the strap to the gun. The tail of the thumb-piece is enlarged, so as to afford a good bearing to the thumb, and is beveled downward and inward on its upper side. This affords security against accidental displacement, and yet allows a slight outward and downward pressure with the thumb to start it easily. The strap is made of decarbonized iron, case-hardened. Its rear end is counter-bored for a hub, hollow-milled around the front-side screw-hole in the lock-plate.

The carrier (see plate) consists of a tempered sheet-steel hook, made in two pieces. (A later model is in a single piece.) A is the hook strap passing through the eye *a′* of the back-strap B. These are also fastened together by the rivets D D, passing through the but of the leather carrier-strap E. A passage is thus allowed for the waist-belt F. The button C serves to secure the strap E, and also by means of the inclined thumb-piece on its upper end to spring out the lip G so as to disengage it from the upper side of the cartridge-block. This lip G keeps the block from rising bodily upward, and the broad part of the hook-strap fitting into the carrier-mortise of the block keeps it from tilting endwise.

It is still further secured by the carrier-strap when buttoned down as above indicated. It will readily be seen that from the position of the lip it maintains its hold on the block to whatever extent within the limits of the elasticity of the spring it may be pressed out. The lip follows it up and brings it back to place when the disturbing pressure is removed. The security of the block is, therefore, within limits independent of the strap.

It is proposed that as many of these carriers be worn upon the belt as may be necessary, due regard being had to the size of the men and to the character of the service requiring their use.

For garrison-service, a single block worn on the right side would probably be sufficient. A large quantity could be worn at once by lapping them like shingles. An ordinary man could probably carry seven blocks, (56 cartridges,) and still have room for his bayonet-scabbard, &c.

Should an extra supply of ammunition have to be carried, it can be put in ordinary leather cartridge-boxes holding two or three blocks apiece. I have presented samples of these. The blocks are kept separate by short brass partitions in the end of the box. They are taken out by a strap which passes under the blocks, and is fastened at the inner end to the part of the box next the body, and has the outer end hanging loose outside.

Belt-plate.—I desire also to call your attention to my belt-buckle, which is of the old S-hook pattern, stiffened and made distinctive by the introduction in the pattern of a letter U. The U. S. part has fastened to it a buckle-tongue, by which its position on the belt can readily be adjusted; or it can be removed entirely to put on or take off the carriers. The other end of the fastening is permanently sewed to the belt; near it is a movable leather slide, into which the free end of the belt passes when it is fastened. The S hooks downward so that the weight of the load tends to keep it in place.

There are loops for the knapsack-straps as used on the present accouterments.

This fastening should be made of bronze, cast under pressure, or of phosphorous or aluminum bronze. The former can be furnished for $12.50 per hundred, in the size which I submit. This bears a weight of 50 pounds without straightening. It could be made heavier and stronger, if desired. Any form of waist-plate could be used with the carriers, provided that one end is unincumbered so that they could be slipped on.

Weights.—In round numbers, the weight of either the carrier or the cartridge-block is less than that of a single cartridge.

	Pounds.	Ounces.
Gun-attachment, about		2
One cartridge		$1\frac{4}{10}$
Block full, &c		13
Block empty		$1\frac{1}{4}$
8 cartridges		$11\frac{1}{2}$
6 blocks full, &c	4	14
7 blocks full, &c	5	11
1 carrier		$1\frac{1}{8}$
6 carriers		$6\frac{3}{4}$
7 carriers		$7\frac{7}{8}$
1 block and carrier, filled		$14\frac{1}{8}$
Same empty—dead weight		$2\frac{3}{8}$
6 carriers and blocks, filled	5	$4\frac{3}{4}$
Same empty—dead weight		$14\frac{1}{4}$
7 carriers and blocks, filled	6	$2\frac{1}{2}$
Same empty—dead weight	1	$0\frac{5}{8}$
Belt-buckle		$2\frac{1}{2}$

Claims.—Having described my inventions, I will state what I consider their special advantages.

First. The *cartridge-block alone:*

I. It affords by itself a good package for the cartridges. It is nearly indestructible in transportation or by wet; it keeps the cartridges from jostling together, and thereby, as has been shown by experience, endangering their surety of fire. It also protects them from dust and sand, quite as injurious to the gun as moisture would be to the cartridge.

II. It is a convenient package in shape and size, if an extra supply of ammunition had to be carried in the men's pockets.

III. It allows the cartridge to project enough for a good, firm grip. In cold weather this might be essential.

IV. It is not costly.

Second. The *block combined with the gun:*

I. A considerable increase in the possible rapidity of fire, as shown by your experiments, in which eight shots were fired in twenty seconds—starting with the chamber empty.

II. The possibility of controlling this increase of rapidity by officers in charge of men so equipped. The order to "fix blocks" need no more be anticipated than that to fix bayonets. Under ordinary circumstances the men would use from the belt. With magazine-guns this rapidity is uncontrollable, as it is impossible to see whether the magazines are used or not.

III. A very marked advantage is found in firing lying down. In this position it seems probable that much of the firing of the future is to be conducted. The only portion of a man so firing which it is at all necessary to move is his right arm. If an isolated skirmisher, he need not twist or roll over to get at his back or side for ammunition, and thereby attract attention.

IV. The cartridges are immediately in front of the firer, under his eye. He sees just where they are, and how many are left him. I have frequently heard of troops engaged in intrenchments spreading, for convenience, their cartridges on the parapet in front of them. In a similar case, a man provided with the block has all this facility of manipulation, with this additional advantage: that, if obliged to change his position hurriedly, he does not have to leave his ammunition behind him, but carries it with the gun to which it belongs.

V. Pickets or other troops exposed to surprise may sleep with their belts off if they have their blocks fixed. In case of a surprise, they have but one thing to look for—the gun. There would be no more necessity of looking for the cartridge-box than if they had loaded revolvers instead of rifles, while, owing to the guns not being loaded, the liability of accident would be diminished.

VI. It protects the hand from burning on the barrel. After a few shots have been fired from the new Springfield rifle, especially on a hot day, the barrel becomes so hot that it can hardly be touched. The block, when fixed, prevents the hand from touching it if the thumb be properly laid along the stock. The board had an opportunity of observing this feature when I first met them in September. Ordinary target-firing, without any attempt at rapidity, soon made the barrel warm.

The English war department has consequently been obliged to issue leather pads to buckle over the barrel at the grip. This is a mere expedient, and will probably be found to get out of shape when wet, and also to hurt the hand where the buckle comes. The barrel is covered half-way up with wood by Westley Richards for this purpose. Unless fragile this is very cumbersome, and, like the pad, is there when not needed. With the cartridge-box, *it is never so much needed as when it is used.*

VII. The weight of the block full of cartridges when fixed on the gun diminishes materially the recoil at the moment of firing. By experiment it was found that without the block the recoil is 174 pounds; with it full it is six pounds less.

Now, as this is about the quantity by which the recoil of the cal. .45 arm exceeds that of the cal. .50, and as the recoil of the cal. .50 was often objected to by the troops, and the carbine-cartridges asked for in place of the musket-cartridge, it would seem reasonable to allow this some weight; particularly as the diminution of recoil is accomplished without the sacrifice of any of the good qualities of the ammunition by reducing the charge, as has been proposed in England, or without increasing the weight of the gun, as has also been proposed there.

VIII. The change in the gun is slight; it will not add more than forty to fifty cents to its cost, and, in combination with the form of the block, give a perfectly solid fastening, so that the block can only be unwittingly removed by destroying it.

Third. The *block in combination with the carrier:*

I. It is one of the least heavy methods proposed of carrying cartridges.

II. The weight is well distributed about the person around the waist, where experience has shown it can be most easily carried.

III. When the block is exhausted it is thrown away, leaving nothing but the carrier to transport. With the ordinary cartridge-box one has to carry as much dead weight for a single cartridge as for a box full.

IV. It fits snugly to the body; does not project, as does the ordinary box.

V. The weight can be shifted on the belt to relieve the waist if fatigued.

VI. It does not interfere with the belt in its functions as a belt. The carriers can all be taken off for parade or drill.

VII. No other belt is required for escort or scouting duty than that used in garrison.

VIII. With the cap on, whether detached from the block or not, and the strap buttoned down, the cartridges cannot fall out.

IX. Owing to the slitting of the holes and the tightness with which the cartridges can consequently be packed, and also to the security with which the carrier holds the block, without using the strap the cartridges can be taken out singly, as in the loop-belt of the plains. The strap is only an accessory. Even without it and the cap, the cartridges are as safe as they are in the loop-belt. With the strap and the cap they are perfectly secure.

X. The carrier, when empty, forms a convenient attachment for any little articles which it may be desired to carry—the tin drinking-cup, &c.

XI. Its cost is slight; it is almost imperishable, and takes but little room in store and transportation.

XII. The block can be readily placed into and removed from the carrier.

The *belt-buckle* is light, cheap, and ornamental. It is protected by the flap from wearing or soiling the clothing.

Directions.—To put the blocks into the carriers:

Slide all the carriers to the right side as near to the belt-plate as possible. Detach the rearmost one two or three inches to the rear. Take a block in the right hand, with the cap next the palm of the hand, and with the thumb resting in the carrier-groove. Hold the block horizontal, so that the mortise comes opposite to the body of the hook-strap of the carrier, the irons uppermost, the bottom of the block against the body. Raise the top of the block so as to roll it into place and to press out the movable portion of the hook-strap, and then slip it down into the carrier as far as it will go.

If necessary, press in the button so that the lip will cut through the paper label; button down the strap; slide the carrier to the opposite end of the belt, and continue as before with the others.

The irons are always next the body.

The cap may be detached before putting it into the carrier.

To remove the block from the carrier—

Hold the musket as at an "order" with the left hand; unbutton the strap of the block nearest to the belt-plate with the right hand, and tuck the strap between the belt and the body; place the right thumb on the upper side of the button, the fore-finger extended along the block, the other three fingers beneath it; press out the button with the thumb until the lip is clear; lift out the block with the fingers beneath it, guiding it with the fore-finger and palm of the hand.

To fix the block—

Hold the piece in the position for loading; open the cam to its full extent; insert the recoil-plate under the lip of the recoil-head as far as it will go, holding the block flat against the gun, pointing downward and forward; press the rear end downward until the nib of the back plate rests on the cam; turn up the thumb-piece of the cam.

Take off the cover by pulling on the string. If the cartridges stick tight, give them a wrench with the hand until the wood is heard to crack. In loading keep the muzzle well depressed, level with the knee. The hand should always grasp the block in firing. Take the nearest cartridges first, successively.

To remove the block—

Open the cam to its full extent; raise the rear end of the block and remove it.

The motions and fastenings of the cartridge-block are like those of the breech-block of the gun. *It always pivots on the forward end.*

The slitting of the blocks is to allow for moisture. So prepared, wet does not affect their hold upon their contents in the slightest degree. It also serves to start them in their holds, if they should fit tight, by wrenching the row of cartridges sideways slightly.

HENRY METCALFE,
Lieutenant of Ordnance.

Capt. M. H. STACEY,
Recorder Board on Infantry-Equipments,
Watervliet Arsenal, West Troy, N. Y.

P. S.—I estimate the cost as follows:

	Cents.
Block, complete	2½ to 3
Carrier, complete	8 to 10
Strap on gun	40 to 50
Belt-buckle, of bronze	12½

REPORT.

WATERVLIET ARSENAL, WEST TROY, N. Y.,
November 24, 1874.

SIR: The board on infantry-equipments, convened by paragraph 14, Special Orders No. 120, dated Adjutant General's Office, Washington, June 1, 1874, have the honor to state that they have carefully examined the various subjects submitted for their consideration, and respectfully transmit their report.

Many different samples of knapsacks, haversacks, cartridge-boxes, belts, &c., have been presented for our inspection, and out of the number we have selected those which, in our judgment, seem best adapted for the use of troops serving as infantry.

In our decisions we have been governed by the result of our own experience with troops in a great variety of service, by the reports from officers of the Army submitted by the Chief of Ordnance, and the very able and comprehensive report on this subject by a board of officers of the British army, of which Major General Eyre was the president.

The first object the board had in view was to lessen the weight of the pack heretofore carried by our soldiers, without impairing their efficiency or interfering with their comfort and health; and we are of the opinion that in the brace-system and appendages, invented by First Lieut. George H. Palmer, of the Sixteenth Infantry, most, if not all, of the requirements of the service are met.

The *equipment* consists of carrying-braces, blanket-straps, clothing-bag, and haversack, the whole weighing about three pounds and a half.

The *carrying-braces* are composed of a back-pad about four inches wide at the top, six and a half inches wide at the bottom, and three and three-quarters inches from top to bottom, made of two thicknesses of stout leather sewed together. To this are riveted four straps, one at each corner, about one inch in width—two straps for each shoulder—the outside strap being about one foot in length, the inner one about fifteen inches. This strap is narrowed down, passed through a brass ring, and is then doubled back, terminating in a tongueless buckle; the outer strap is passed through this buckle and is riveted to the outside of the inside shoulder-strap about three inches above the brass ring.

Two waist-belt straps of leather, five-eighths of an inch in width and 20 inches in length, are secured to the brass rings, and are attached to each side of the waist-belt plate. In addition to this are two straps riveted to the lower part of the pad 1 inch apart, five-eighths of an inch wide and 14 inches long.

On the upper corners of the back-pad are two brass D rings, held by the same rivets that fasten the upper shoulder-straps, through which the blanket-straps are passed. A strap 8 inches long and looped at each end is placed on the blanket-straps and passes underneath the straps attached to the lower part of the back-pad supporting the bags, for the purpose of holding the blanket more firmly in place when marching in double time.

Two straps are attached to the front rings by brass hooks for supporting the front corners of the haversack and clothing-bag.

The *clothing-bag* is made of stout canvas duck with India-rubber flap, cut 16¾ inches long by 13⅜ inches wide, and laps backward over the canvas ¾ of an inch. This flap has an inside pocket 12 inches deep and nearly as wide as the flap.

The main pocket of the clothing-bag is 12½ inches deep in front by 11⅜ inches wide at the bottom and 10½ inches wide at the top. The top is strengthened by a border of white leather ¾ of an inch wide extending around the bag.

The gusset is 38 inches long by 5⅜ inches wide in middle and 4¼ inches at the ends, and tapers back from ends 8 inches.

It also has a pocket for extra ammunition, cut 10⅞ inches wide by 7 inches deep, with selvage top. Also two straps fastened to the flap, and which buckle under the clothes-bag; also two buckles at the corners to attach the bag to the brace-yoke.

The *haversack* is made of the same material as the clothing-bag, but is a little smaller. The flap is cut 14⅜ inches long by 13¼ inches wide. The front is cut 12 inches deep by 9⅞ inches wide. It has an outside pocket for meat-can and plate combined, 9¼ inches wide by 10 inches deep, rounded at the bottom, with selvage top. Gusset 32½ inches long by 3½ inches in width in the middle and 3⅛ inches at ends, tapers back from the ends 5 inches. Three-eighths of an inch for all seams included in these dimensions. The haversack has a buckle at each upper corner to attach it to the yoke, a buckle and strap on flap, and a strap to hold the clothing-bag and it together, to secure steadiness. The haversack belonging to this equipment has been constructed under the directions of the board, so as to contain a knife, fork, spoon, meat-can, and plate, combined, with a tin cup attached to the strap, and may be carried over either shoulder or attached to the brace-yoke. The strap for the shoulder is much longer and broader than those now furnished, and is ajustable to the size of any man by means of a double-barred brass buckle, invented by Maj. Alex. Chambers.

The *knife, fork, and spoon* in the model were manufactured, according to the specifications of the board, by Lamson, Goodenew & Co., of New York. They should be furnished by the Government, and cost only about $9 per gross.

The *meat-can and plate combined* consists of two oval dishes made of block-tin, one deeper than the other, which fit together, forming a meat-ration can of the following dimensions:

Length, 8 inches; width, 6½ inches; depth of whole can, 1½ inches when closed; the lower dish to be 1 inch in depth; the plate ¾ of an inch in depth.

To the deeper dish or plate is attached a light iron handle, which folds over and holds the two together. The one with the handle may be used to eat soup out of; as a frying-pan; or to warm up cold food, and many other purposes that will suggest themselves when it is used.

The board recommend that the knife, fork, meat-can, and tin cup be furnished by the Ordnance Department and issued as other ordnance-stores.

The *canteen* submitted by the Ordnance Department meets with approval, and is recommended for adoption with the broad strap and the Chambers buckle, as per accompanying sample. (See Plate.)

The *waist-belt and plate* submitted by Col. P. V. Hagner, Ordnance Department, meets the requirements of the service, and is recommended for adoption. Sample forwarded.

When the bayonet is carried, we recommend that the scabbard shall be of *steel*, as is now issued.

When the *trowel-bayonet* is carried, the scabbard now being manufactured at this arsenal seems to be suitable.

We desire to remark in this connection that if the trowel-bayonet is substituted for the triangular bayonet throughout the Army, our soldiers will be deprived of a very efficient defensive weapon without providing them with an effective intrenching-tool. A bayonet has been found to be always more or less necessary, but in our service an intrenching-tool might not be required for use once in ten years. Would it not be better to leave the bayonet as it now is, and, when necessity requires, add to the soldier's equipment a light, effective intrenching-tool, something similar to the picket-shovels used in the Army toward the close of the late war?

The board recommend that the *sword* shall no longer form a part of the equipment of company sergeants.

The board recommend for adoption the *cartridge-box* invented by First Lieut. Samuel McKeever, Second Infantry.

It is made of leather, is 6⅜ inches long, 3¼ inches wide, and 1½ inches thick. It is carried on the waist-belt by two loops, opens from the top, the outside half working on a hinge formed by a brass rod running under the box and holding it together. The cartridges are held in webbing loops, ten in each section of the box, and are readily extracted from the box, a bellows arrangement allowing the tops of the cartridges to incline forward when the box is open. It has been improved by the addition of a brass escutcheon, and by making the bellows of russet leather, which is stronger than the kind used by Lieutenant McKeever, and is not so liable to corrode the cartridges. This box posseses all the merits of the thimble, or service, or Hazen's belt, which has been highly recommended by many officers of the Army, with the additional advantages of protecting the cartridges from the danger of loss, or exposure to dust or moisture.

No provision has been made in this box for a screw-driver, but, when necessary to carry one, a cartridge may be taken out and the screw-driver inserted in its place.

The following are some of the merits of the Palmer brace system:

The *back-pad* gives additional bearing-surface for the weight carried. Its shape enables the shoulder-straps to be riveted in such a manner as to separate them on the back and shoulders. The manner of connecting the front ends of the shoulder-straps secures a bearing on each.

The *double shoulder-straps* have more bearing-surface and press into the shoulders less than single straps, and are readily moved from place to place on the shoulders, to give ease to the wearer. They cannot slip off the shoulders, being retained by their connection with the back-pad.

The *braces* adjust themselves to fit any size or form of shoulders, and enable a load to be carried without compressure of the waist or chest, or bearing down on the hips, or pulling backward of the shoulders, leaving the body, arms, and shoulders free in their movements. In other words, the weight is brought to bear vertically upon the shoulders, without deranging the equilibrium of the body, with its attending discomfort and ultimate permanent injury to vital organs.

The *bags* should be worn well up under the arms, the front straps being buckled a little shorter than the rear straps, but they may be worn at any height desired by letting out or taking up the straps supporting them. But one bag may be worn, (on either side,) the rear strap supporting it being buckled shorter than the front one. In an emergency both bags can be filled with rations, leaving the extra clothing in camp, thus enabling the soldier to carry six or eight days' rations.

The *blanket* should be folded flat, about eleven or twelve inches high, and fourteen or fifteen inches wide. It would be well to wrap the poncho or shelter-tent around it. The blanket may be carried at the side, taking the place of one of the bags, the straps on the back-pad and shoulder-strap being buckled into the buckles on the blanket-strap.

One or four cartridge-boxes may be carried. The overcoat, folded, may be buckled under the flap of the haversack or clothes-bag.

The equipment is put on by holding the shoulder-straps in the hands, leaving the right-hand strap unhooked, the bags in front of the body, flaps to the rear, and swinging them round to the left on the back, at the same time turning them, the left arm passing under the shoulder-strap, the right hand passing over the head and under the right shoulder-strap; the waist-belt straps are then buckled, and the right-hand strap is hooked.

In this equipment the means are provided for carrying the following articles:

A woolen blanket, rubber poncho, (an overcoat for winter,) one pair of extra shoes and stockings, an extra shirt, extra drawers, towel, soap, comb. and brush, three (or six) days' rations, and from twenty to eighty rounds of cartridges; the maximum weight of which, including rifle, bayonet, and scabbard, forty rounds of ammunition, and three days' rations, is thirty-eight pounds; ordinarily it would be reduced to twenty or twenty-five pounds.

The *poncho* submitted with this equipment was especially prepared by the Goodyear India-Rubber Manufacturing Company, at the request of the board, and we recommend that the poncho furnished be of this pattern.

It is not intended that the entire equipment should be always worn, or that all the articles should of necessity be in the clothing-bag; on the contrary, it is proposed to carry only one cartridge-box on ordinary occasions in garrison, and when in the field only such things as the nature of the duty may require.

Many officers have recommended that the knapsack. or valise, be abolished altogether, and in its place our soldiers, when in the field, should carry simply a change of underclothing rolled in their blankets and carried over the shoulder *en bandolier.*

There are so many objectionable features to this method that it would seem almost supererogatory to enumerate them; but in view of the prominence which has been given to this matter, the board feel called upon to indicate the objections they have to it.

In the first place, then, the custom originated in necessity. At the opening of the spring campaigns our soldiers, heavily weighted with the old-fashioned knapsacks, with the accumulations of the winter, after the first few miles, exhausted by their packs, availed themselves of a favorable opportunity to stop by the road-side, and to take from their knapsacks a few things, which they rolled in their blankets, the ends of which they tied together, and slung over their shoulders, abandoning all other articles of clothing. Any one who will take the trouble to try this on a warm day will find himself enveloped in blankets, and although he may scarcely feel the weight on his shoulder, his breast will be oppressed, his clothing will be bound to him, and he cannot handle his piece with any degree of facility.

In garrison we recommend that each soldier be provided with a *box* or *locker* of the following dimensions, to store his full-dress uniform and extra clothing.

Dimensions of the box:

Length, 24 inches.
Breadth, 12 inches. } In the clear.
Height, 10 inches. }

To be constructed of pine $\frac{3}{4}$ of an inch thick, with iron hinges 10 inches in length and $1\frac{1}{2}$ wide, with lock and key. These boxes to be permanent fixtures of the barracks.

We recommend that a *box of cleaning-material*, similar in construction to the sample furnished from the National Armory, Springfield, be supplied to each company, in the following quantities:

2 quart-cans of anti-corrosive and lubricating oil.
1 box, holding forty ounces, scouring-material, marked I.

1 box, containing sixteen ounces, polishing-material for leather, marked II.

1 box, holding forty ounces, of whiting.

2 chamois-skins about two feet square.

1 wire scratch-brush.

The board have carefully examined and experimented with the attachment to the Springfield rifle, cal. .45, together with the belt and contrivance for carrying the loaded cartridge-blocks, invented by Lieut. Henry Metcalfe, of the Ordnance Department.

Being satisfied of its great merit, the board recommend that a limited number of the Springfield rifles, cal. .45, to be fixed by the Chief of Ordnance, together with the belt, blocks, and holders, be prepared and issued to different regiments for trial in actual service.

A sample of the whole, together with a rifle prepared with the attachment, is herewith submitted.

The board recommend that water-proof paper be used to cover the blocks, in order that they may be rendered impervious to the action of water.

In concluding our report, we desire to remark that we have labored diligently to arrive at a satisfactory solution of the difficult problems submitted to us, and while not claiming perfection as the result of our investigations, we feel assured that the principles involved in the equipment are correct, and it remains for practical trials in actual service to demonstrate what further improvements can be made.

We desire, also, to express our thanks to Col. P. V. Hagner, commanding Watervliet Arsenal, for valuable suggestions and assistance, and to other officers of the Army who have aided us materially by giving in detail the result of their experience.

W. R. SHAFTER,
Lieutenant-Colonel Twenty-fourth Infantry, President of Board.
A. McD. McCOOK,
Lieutenant-Colonel Tenth Infantry.
T. C. ENGLISH,
Lieutenant-Colonel Second Infantry.
ALEX. CHAMBERS,
Major Fourth Infantry.
M. H. STACEY,
Captain Twelfth Infantry, Recorder.

The CHIEF OF ORDNANCE,
Washington, D. C.

[First indorsement.]

ORDNANCE OFFICE, *December* 14, 1874.

Respectfully submitted to the Secretary of War, for approval of the recommendations of the board.

S. V. BENÉT,
Brigadier-General, Chief of Ordnance.

Respectfully referred to the Adjutant General, to submit to the consideration of the General of the Army.

By order of the Secretary of War:

H. T. CROSBY,
Chief Clerk.

DECEMBER 19, 1874.

[Second indorsement.]

WAR DEPARTMENT, ADJUTANT GENERAL'S OFFICE,
Washington, December 22, 1874.

Respectfully referred to the General of the Army for his consideration.

By order of the Secretary of War:

E. D. TOWNSEND,
Adjutant General.

[Third indorsement.]

HEADQUARTERS OF THE ARMY, SAINT LOUIS, MO.,
December 26, 1874.

Respectfully returned. The officers composing this board have had a large and wide experience, and their conclusions are entitled to full weight.

Their recommendation that in all permanent barracks should be provided boxes in which to stow away the clothing of the men is good, and is approved. Instead of a common lock, I would suggest a staple and hasp, leaving each man to provide his own padlock. In practice, the keys are invariably lost. In like manner should be issued to each man, as a part of his outfit, the mess-kit herein provided for. After a first issue he should be required to replace lost or broken parts at his own cost.

The braces, knapsack, haversack, and cartridge-box are all approved, and recommended for adoption. I agree with the board that there is danger that in the use of the trowel bayonet, the musket being used as a handle, will bend the barrel and seriously damage it for firing.

W. T. SHERMAN,
General.

[Fourth indorsement.]

WAR DEPARTMENT, ADJUTANT GENERAL'S OFFICE,
Washington, December 30, 1874.

Respectfully returned to the Secretary of War.

E. D. TOWNSEND,
Adjutant General.

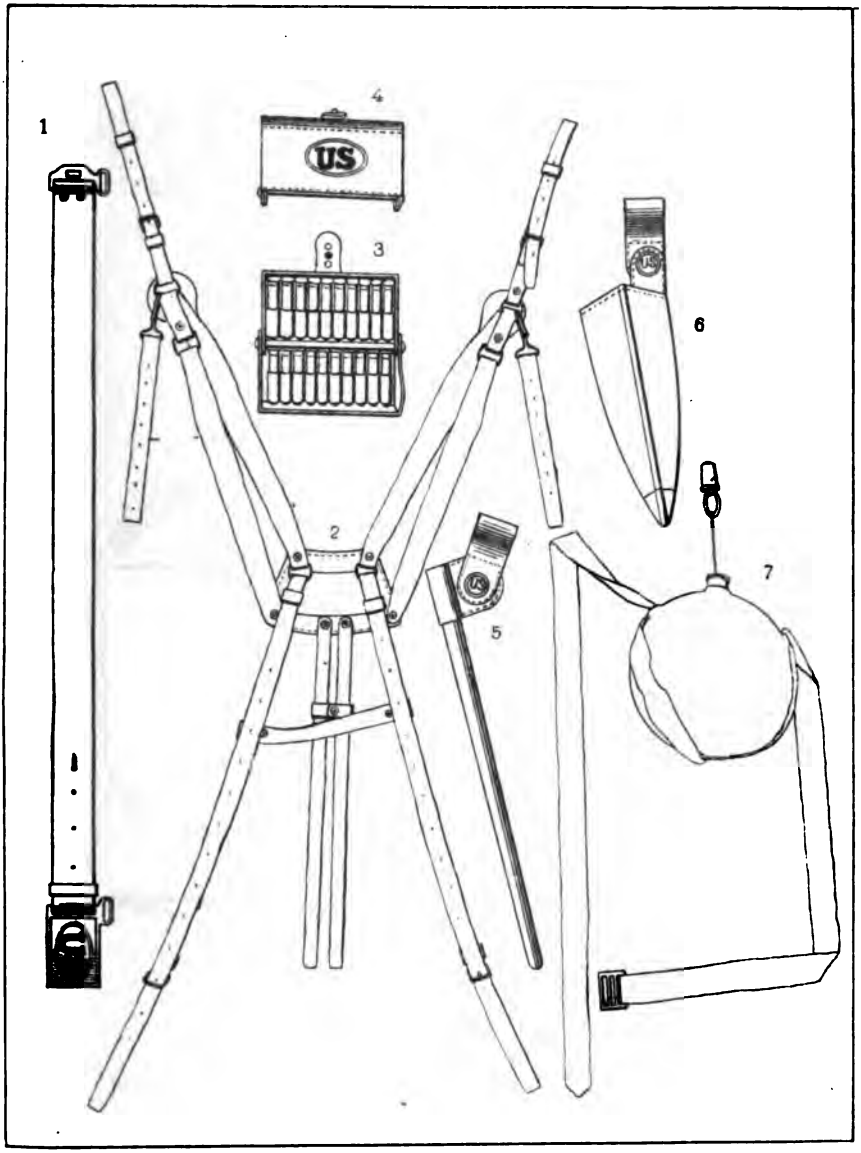
[Fifth indorsement.]

Chief of Ordnance:

The report of the board is approved, as suggested by the General of the Army, with the modifications recommended by him.

WM. W. BELKNAP,
Secretary of War.

JANUARY 4, 1875.



1. WAIST BELT AND PLATE.
2. CARRYING-BRACE.
3. CARTRIDGE BOX, OPEN.
4 CARTRIDGE BOX, CLOSED.
5. BAYONET SCABBARD.
6. TROWEL BAYONET SCABBARD.
7. CANTEEN, STRAP AND BUCKLE.

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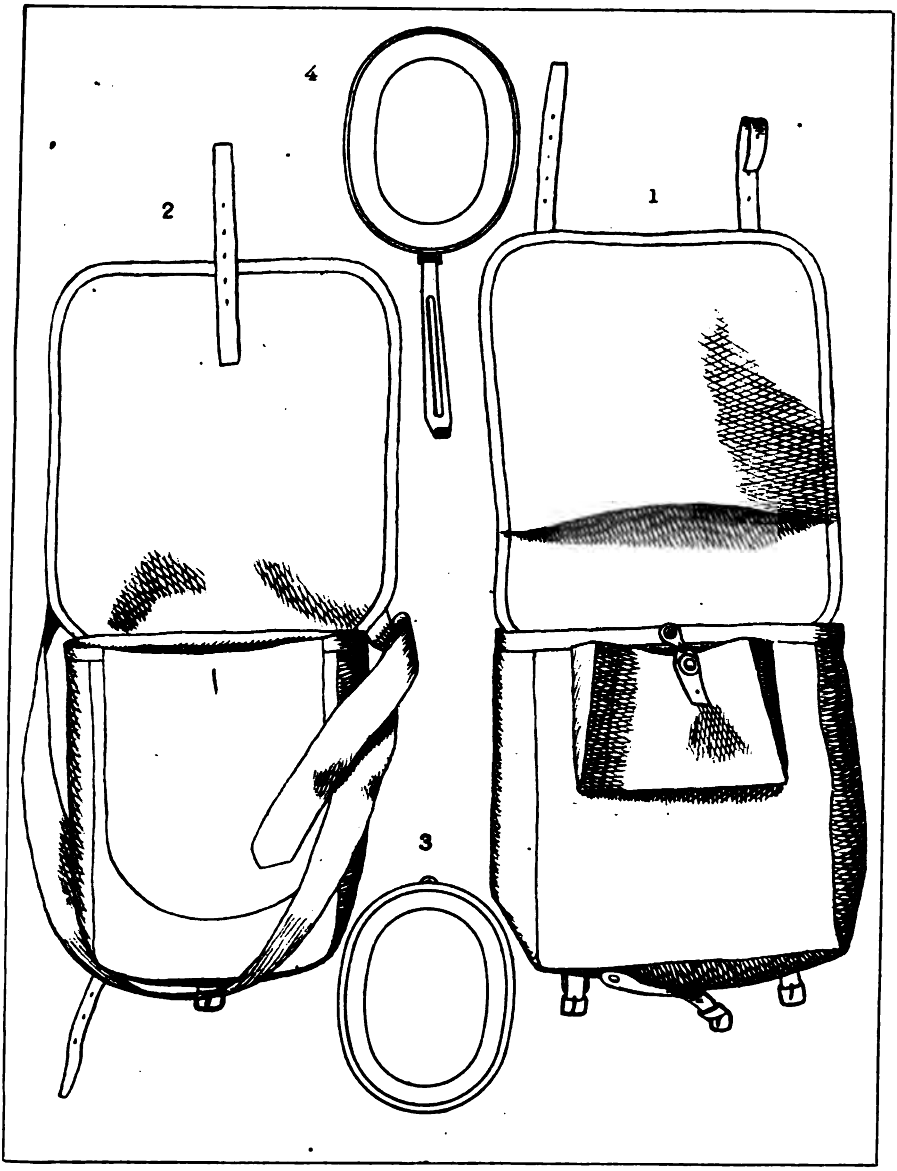

1. CLOTHING BAG, OPEN.
2. HAVERSACK, OPEN.

MEAT CAN. { 3. PLATE.
4. SOUP PLATE

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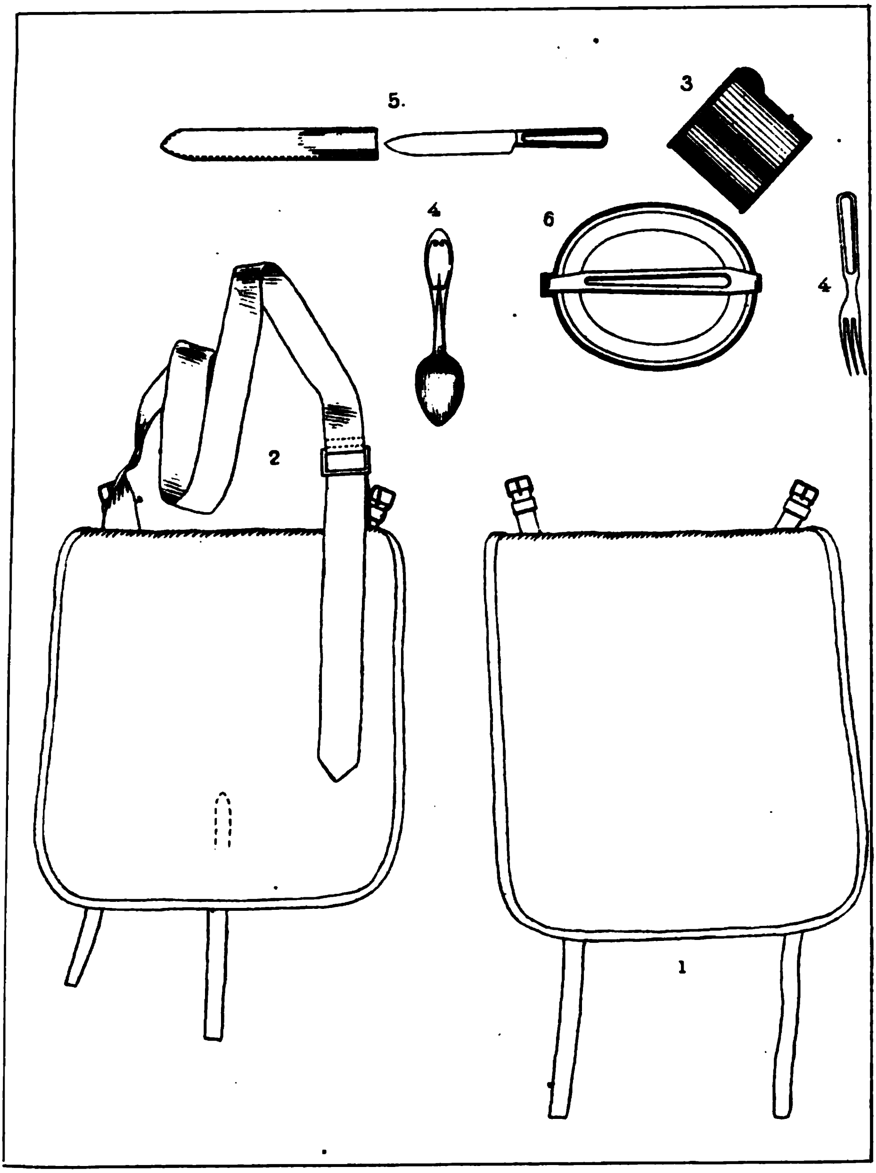

1. CLOTHING BAG.
2. HAVERSACK, STRAP AND BUCKLE.
3. TIN CUP.
4. FORK. SPOON.
5. KNIFE AND KNIFE-SHEATH.
6. MEAT CAN, CLOSED.

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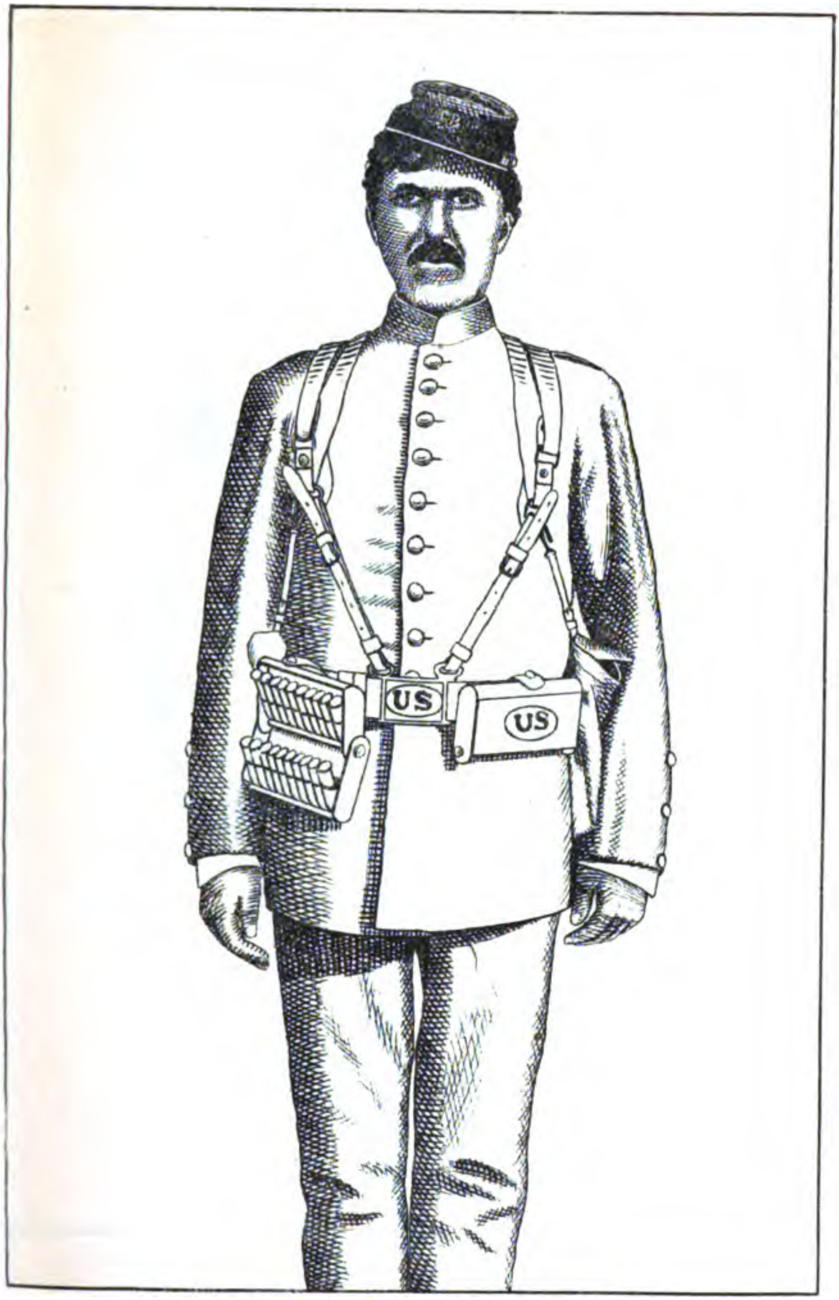

FRONT VIEW.

SHOWS CARTRIDGE BOXES, ONE OPEN, ONE CLOSED.
WAIST-BELT-PLATE AND STRAPS TO PLATE FROM BRACE-YOKE

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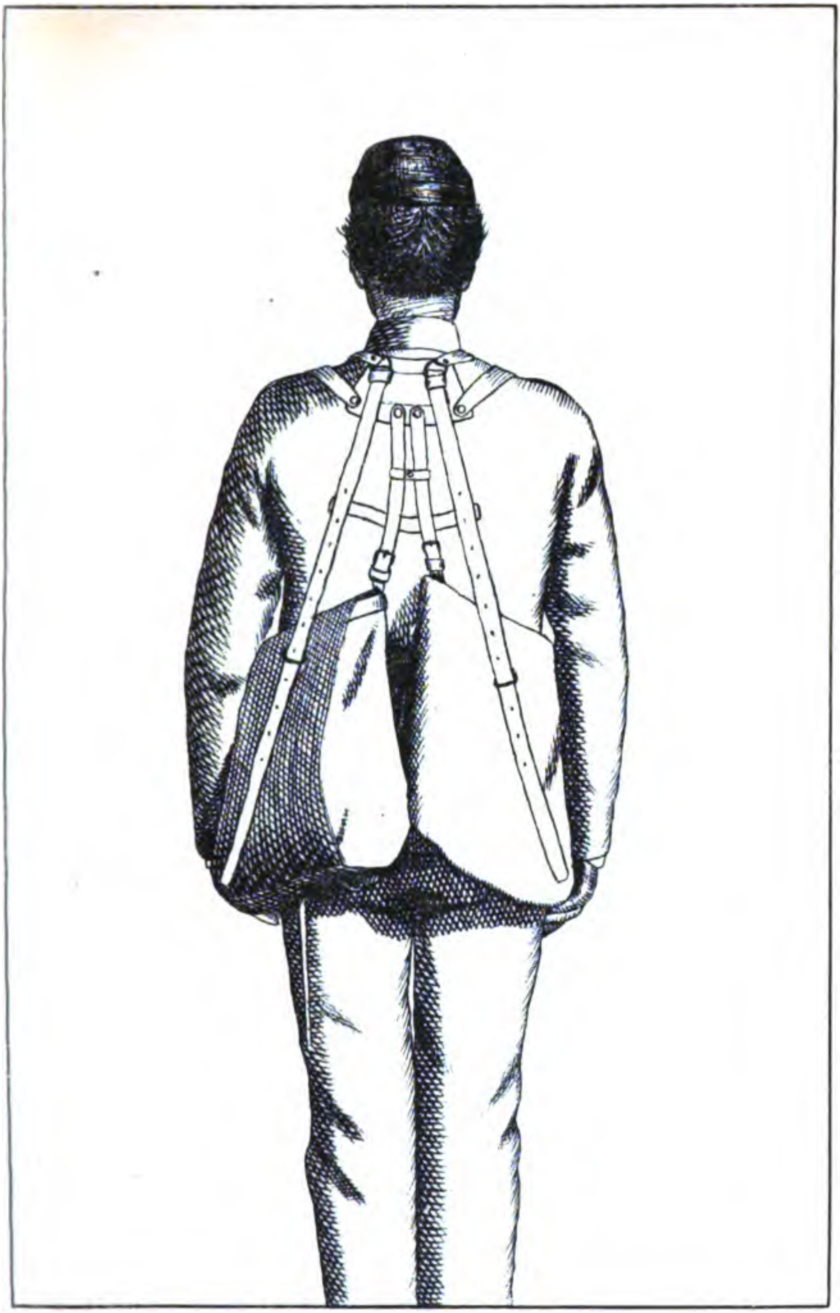

REAR VIEW.

SHOWING BACK-PAD, BLANKET-STRAPS, AND METHOD OF ATTACHING CLOTHING-BAG AND HAVERBACK.

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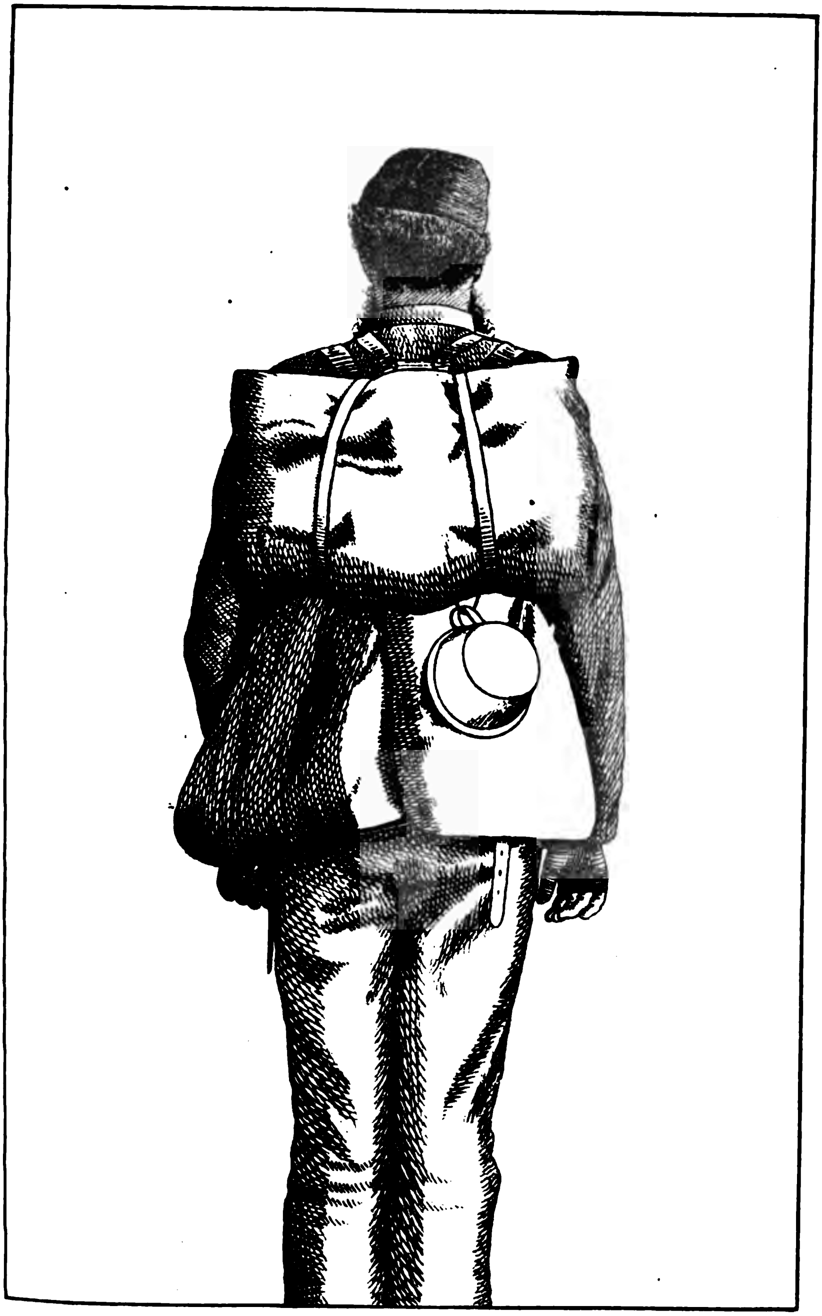

REAR VIEW.

SHOWING BACK-PAD, BLANKET-STRAPS, AND METHOD OF ATTACHING CLOTHING-BAG AND HAVERSACK.

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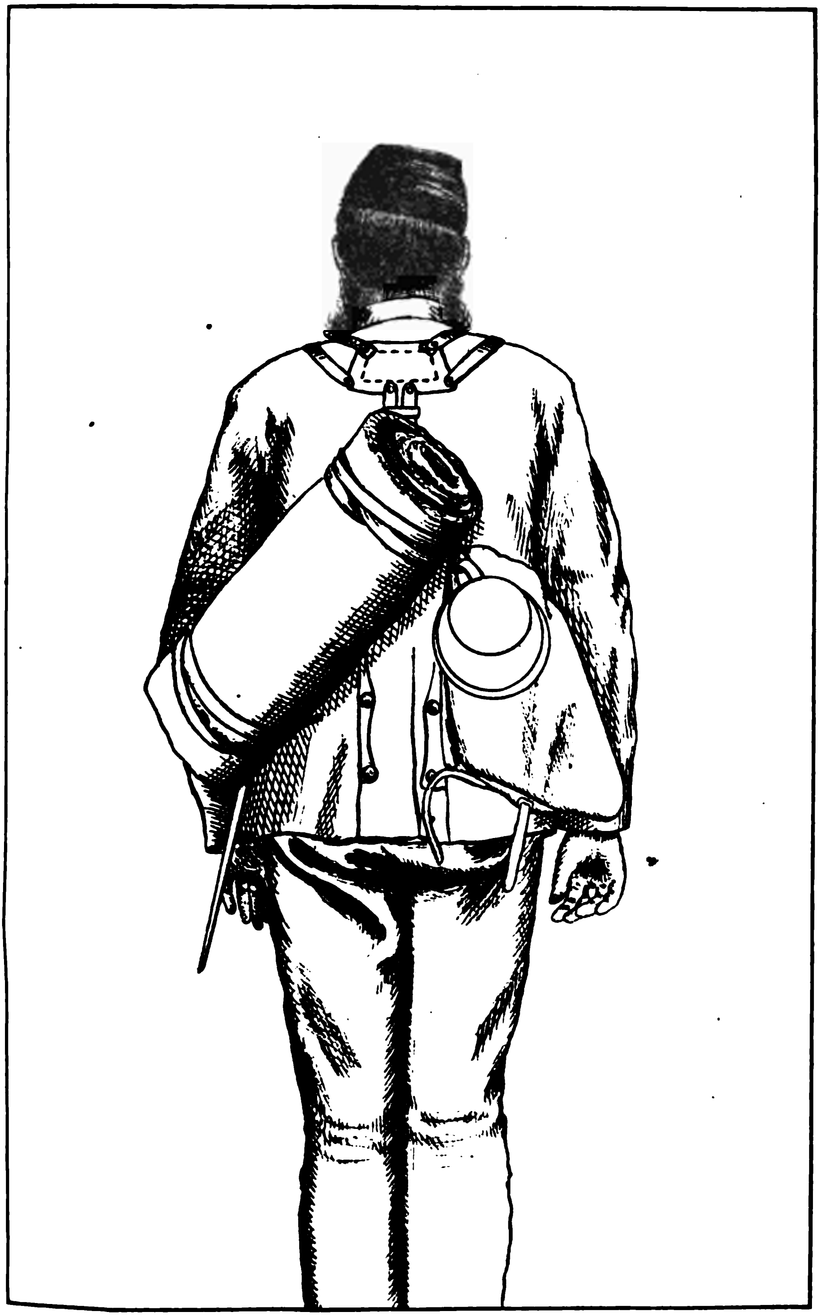

REAR VIEW.

SHOWING BLANKET ROLLED, AND HAVERSACK.

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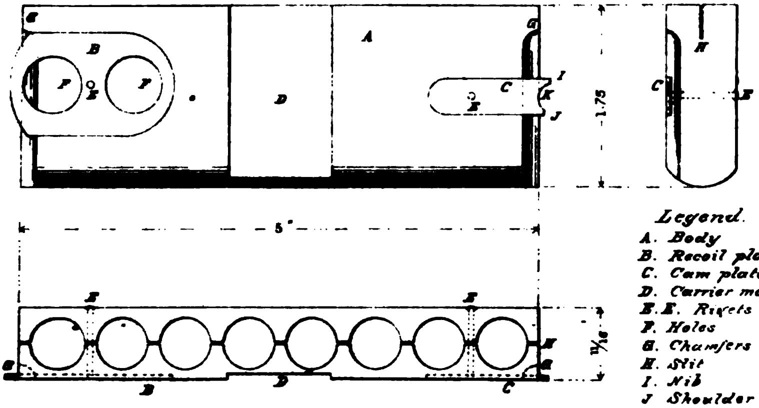
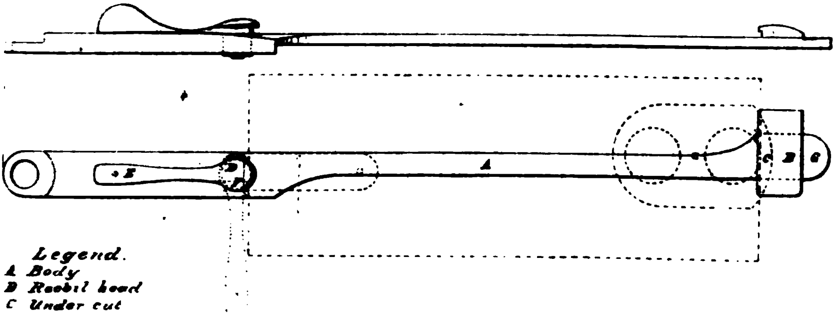
LIEUT. HENRY METCALFE'S
CARTRIDGE BLOCK



Legend.

A. Body
B. Recoil plate
C. Cam plate
D. Carrier mortise
E.E. Rivets
F. Holes
G. Chamfers
H. Slit
I. Nib
J. Shoulder
K. Cam recess

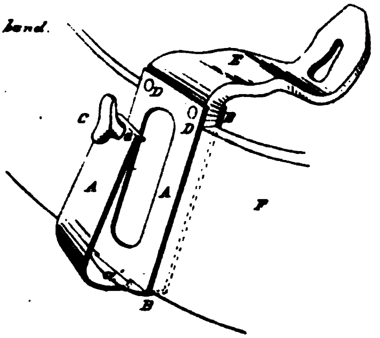
STRAP ON GUN



Legend.

A Body
B Recoil head
C Under cut
D Cam
E Thumb piece
F Flat on cam
G Tongue for lower band.

CARRIER



Legend.

A. Hook strap
a. Eye of back strap B
B. Back strap
C. Button
D.D. Rivets
E. Carrier strap
F. Waist belt
G. Lip on hook strap.

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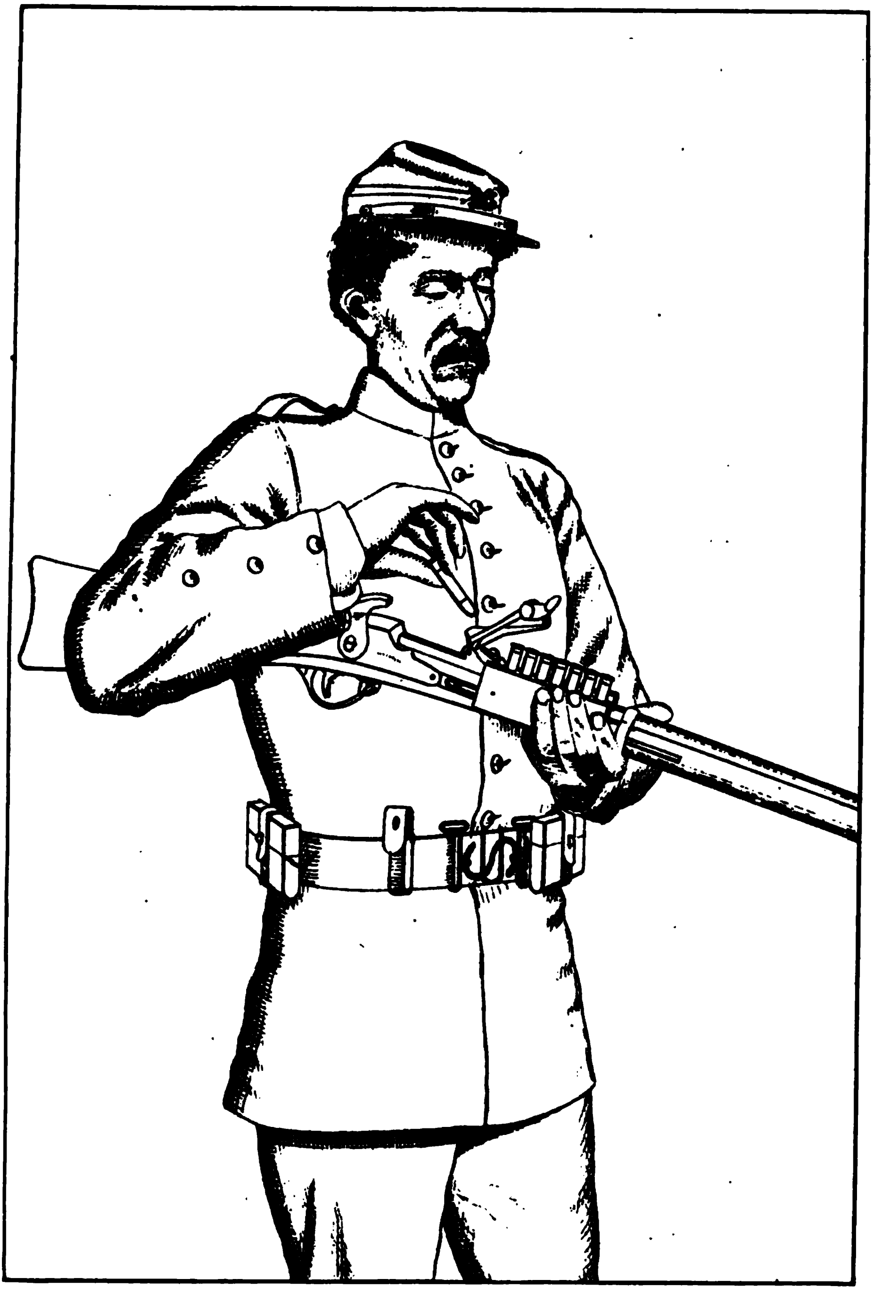

LIEUT. HENRY METCALFE'S CARTRIDGE BLOCK ATTACHMENT ON RIFLE
WAIST-BELT AND PLATE, CARTRIDGE BLOCKS ATTACHED TO WAIST-BELT.

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APPENDIX E.

ARMAMENT FOR SEA-COAST DEFENSE.

Message from the President of the United States, relative to the condition of the armament of our fortifications and the necessity for immediate provision by Congress for the procurement of heavy cannon.

JANUARY 20, 1875.—Referred to the Committee on Military Affairs and ordered to be printed.

To the Senate and House of Representatives :

In my annual message of December 1, 1873, while inviting general attention to all the recommendations made by the Secretary of War, your special consideration was invited to "the importance of preparing for war in time of peace by providing proper armament for our sea-coast defenses. Proper armament is of vastly more importance than fortifications. The latter can be supplied very speedily for temporary purposes when needed. The former cannot."

These views gain increased strength and pertinence as the years roll by, and I have now again the honor to call special attention to the condition of the "armament of our fortifications," and the absolute necessity for immediate provision by Congress for the procurement of heavy cannon. The large expenditures required to supply the number of guns for our forts is the strongest argument that can be adduced for a liberal annual appropriation for their gradual accumulation. In time of war such preparations cannot be made, cannon cannot be purchased in open market, nor manufactured at short notice; they must be the product of years of experience and labor.

I herewith inclose copies of a report of the Chief of Ordnance and of a board of ordnance officers on the trial of an 8-inch rifle converted from a 10-inch smooth-bore, which shows very conclusively an economical means of utilizing these useless smooth-bores and making them into 8-inch rifles capable of piercing 7 inches of iron. The 1,294 10-inch Rodman guns should, in my opinion, be so utilized, and the appropriation requested by the Chief of Ordnance of $250,000 to commence these conversions is urgently recommended.

While convinced of the economy and necessity of these conversions, the determination of the best and most economical method of providing guns of still larger caliber should no longer be delayed. The experience of other nations, based on the new conditions of defense brought prominently forward by the introduction of iron-clads into every navy afloat, demands heavier metal and rifle-guns of not less than 12 inches in caliber. These enormous masses, hurling a shot of 700 pounds, can alone meet many of the requirements of the national defenses. They must be provided, and experiments on a large scale can alone give the data necessary for the determination of the question. A suitable proving-ground, with all the facilities and conveniences referred to by the Chief of Ordnance, with a liberal annual appropriation, is an undoubted necessity. The guns now ready for trial cannot be experimented with without funds, and the estimate of $250,000 for the purpose is deemed reasonable, and is strongly recommended.

The constant appeals for legislation on the "armament of fortifications" ought no longer to be disregarded, if Congress desires in peace to prepare the important material without which future wars must inevitably lead to disaster.

This subject is submitted with the hope that the consideration it deserves may be given it at the present session.

U. S. GRANT.

EXECUTIVE MANSION, *January* 20, 1875.

ORDNANCE OFFICE, WAR DEPARTMENT,
December 14, 1874.

SIR: I have the honor to submit for the action of the Secretary of War the following:

I. In my annual report, submitted in October last, I expressed the belief that, prior to the meeting of Congress, much valuable information would be obtained from experiments with certain experimental guns, then nearly ready for trial, as would enable this Bureau to report understandingly on that most important subject, the "armament of our fortifications." Although the information is not as complete as was expected, sufficient has been done and reported upon which to base the following recommendations.

There are at present in our forts the following heavy guns:

321 15-inch Rodman guns, smooth-bore.
1,294 10-inch Rodman guns, smooth-bore.
90 8-inch Parrott rifles.
40 10-inch Parrott rifles.

These Parrott rifles, even if reliable when using the heavy battering-charges required in modern warfare, of which doubts are entertained, are so few in number as to constitute but an unimportant item among the 4,181 guns required for our forts, when ready for their armament. Rifle-guns ranging from 8 inches to 12 inches in caliber, with power sufficient to penetrate at considerable distances the armor of iron-clad vessels, must be provided. The heaviest rifles are the guns of the present, as they will be of the future, and while smooth-bores may for some time to come play a secondary part, for want of a more powerful weapon, they must inevitably yield to the rifle in every important juncture, as the old smooth-bore musket has given place to the breech-loading rifle in the hands of the soldier. While thus expressing the conviction that the days of smooth-bore ordnance are passing away, I desire to call attention to the fact that the first grand stride toward the introduction of great guns in any service was made in this country by the late General Rodman, of the Ordnance Department, whose reputation as an ordnance officer is world-wide, and that the 15-inch gun he first made in 1861 was the most powerful weapon then known, soon to be surpassed by his 20-inch smooth-bore, made in 1864, weighing 116,000 pounds, and throwing a shot weighing 1,080 pounds. The introduction of iron-clads in modern warfare calls, however, for the penetrating power of heavy rifles, and the smashing and racking effect of a 15-inch smooth-bore must yield to the working energy of a 12-inch rifle that will pierce the thickest iron armor at long distances.

How best and most economically to provide for this great want has exercised the brain and skill of the most distinguished officers in every country, and caused the expenditure of millions of money. There is little doubt that steel is the best material for guns, but the product is by far too costly to be considered now, and, besides, would have to be procured abroad. Wrought-iron guns lined with steel, as adopted by England, have not given that satisfaction that would justify an expenditure of several millions of money in plant for their manufacture. In this country, the success of the Ordnance Department in improving the quality of our cast iron for cannon has been marked and satisfactory, and we may lay claim, with good reason, to the best cast-iron guns in the world. They require, however, to be strengthened when subjected to the enormous strains which as rifles they are to withstand; and the success abroad of lining cast iron with wrought iron or steel, has suggested an easy and economical mode of converting our cheap cast-iron smooth-bores into powerful and efficient rifles. Our trial thus far with a 10-inch Rodman gun lined with wrought iron and converted into an 8-inch rifle gives promise of success; and another lined with steel, now nearly ready for firing, may probably give equal, if not better, results. This 8-inch rifle has already been fired 328 rounds,* with battering-charges of 35 pounds of powder and 180-pound shot, giving an average velocity of about 1,425 feet, and a working energy of nearly 5,000,000 foot-pounds; capable of penetrating seven inches of iron armor at distances from 500 to 1,000 yards. This success enables us at comparatively small cost to utilize the 1,294 10-inch smooth-bore guns, which as smooth-bores are utterly useless against iron-clads, by converting them into 8-inch rifles capable of penetrating 7 inches of iron armor.

The value and interest of this proposed conversion is all the greater from the fact that the casemates of our forts, designed many years since, are too contracted to accommodate a gun of much larger size than the 10-inch Rodman; and this very gun intended for that special purpose can thus be strengthened and increased in power, to meet the greater demands that modern improvements in naval attack and defense make upon it.

In again urging upon Congress the absolute necessity for some action that will enable us to place our forts in fighting condition by providing their armament, I will be excused for stating an undeniable fact, which appears to be entirely ignored, that a fort is worse than useless without guns to arm it; indeed, that it is not a fort at all without its armament—more like a body without a soul; and that other fact, which also seems to be lost sight of, that cannon cannot be purchased ready-made in market, but have to be manufactured specially, and must be provided in time of peace. It is certainly the part of wisdom to be prepared for future wars that occur in the life of every nation, but should our appeals be constantly disregarded and the next war find the country unprepared, and our sea-coast defenseless and at the mercy of an enterprising enemy, the responsibility for all subsequent disasters cannot rest on the Ordnance Department of the Army, nor on the Secretary of War, nor the Executive.

I have, therefore, the honor to recommend that an appropriation of $250,000 be made by Congress for converting smooth-bore guns into rifles by lining with wrought iron or steel.

The above sum will enable us to convert at least 140 guns.

II. In 1872 Congress appropriated $270,000 "for experiments and tests of heavy rifled ordnance." The guns "designated by a board of officers appointed by the Secretary of War," under the provisions of the act, have been in preparation under the supervision of their respective inventors, and the whole number will probably be ready for trial in the early spring. The necessity and convenience of having a proving and experimental ground in near proximity to the city of New York has forced the Department, with your approval, to establish a temporary one on the Government reservation at Sandy Hook, New York Harbor.

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* Up to date, December 19, this gun has been fired 448 rounds.

Even in the trial of the 8-inch rifle, referred to above, this Department has been hampered by the want of funds, and these important experiments, that will eventually lead to a determination of the question so vital to the national defense, have had to be conducted under great embarrassments, and with the rudest appliances and conveniences.

It is expected that by the opening of spring eight guns, varying in caliber from 8 inches to 12 inches, and in weight from 16,000 to 85,000 pounds, will be ready for firing. The firing of a 12-inch rifle is a very expensive business, each round fired costing about $100. As the gun may stand 500 rounds, its trial will cost $50,000, and only in a less degree will the expense be in the trial of guns of smaller caliber.

Funds necessary for this purpose should be appropriated; and, added to this, a sum sufficient to provide all the carriages, depressing and others, butts and platforms, and all the appliances, conveniences, and labor required for the prosecution of such exact and important work.

I know of no military or naval power that has not provided an experimental and proving ground with every facility for conducting trials upon a grand scale; and there is no way of avoiding considerable expenditure, while seeking and obtaining the necessary data from which to draw conclusions, that will lead to such large expenditures in the future in arming our fortifications.

I have, therefore, the honor to recommend that an appropriation of $250,000 be made for proving-ground and experiments and tests of heavy ordnance.

Very respectfully, your obedient servant,

S. V. BENÉT,
Brigadier-General, Chief of Ordnance.

The Hon. SECRETARY OF WAR.

DECEMBER 24, 1874.

The gun up to this date has been fired 513 times, 500 of which with battering-charges. After the most careful examination and measurements, no damage to the rifling or enlargement of the bore can be detected, and the gun apparently is in perfect order—serviceable in every respect.

S. V. B.

REPORT OF TRIAL OF AN 8-INCH RIFLE, CONVERTED FROM A 10-INCH CAST-IRON SMOOTH-BORE RODMAN GUN, BY LINING WITH A COILED WROUGHT-IRON TUBE, INSERTED FROM THE MUZZLE.

ORDNANCE OFFICE, *October* 9, 1874.

SIR: I have the honor to recommend that a board of ordnance officers be convened in the city of New York, on the 21st of October, instant, or as soon thereafter as practicable, for the consideration of such ordnance subjects, and the trial of such of the experimental guns prepared under the "act of June 6, 1872," as may be submitted to it by the Chief of Ordnance, to whom its reports shall be made.

The following-named officers are respectfully recommended for detail:

Maj. S. Crispin, Ordnance Department; Maj. T. J. Treadwell, Ordnance Department; Maj. T. G. Baylor, Ordnance Department; Capt. Geo. W. McKee, Ordnance Department, as recorder.

Very respectfully, your obedient servant,

S. V. BENÉT,
Brigadier-General, Chief of Ordnance.

The Hon. SECRETARY OF WAR.

[Special Orders No. 221.]

WAR DEPARTMENT, ADJUTANT GENERAL'S OFFICE,
Washington, October 10, 1874.

(Extract.)

* * * * * * *

6. A board, to consist of Maj. S. Crispin, Ordnance Department; Maj. T. J. Treadwell, Ordnance Department; Maj. T. G. Baylor, Ordnance Department, and Capt. George W. McKee, Ordnance Department, as recorder, is appointed to meet in New York City, N. Y., on the 21st day of October, 1874, or as soon thereafter as practicable, for the consideration of such ordnance subjects, and the trial of such of the experimental guns prepared under the "act of June 6, 1872," as may be submitted to it by the Chief of Ordnance, to whom its reports will be made.

By order of the Secretary of War.

E. D. TOWNSEND,
Adjutant General.

Report of the trial of an 8-inch rifle converted from a 10-inch cast-iron smooth-bore Rodman gun by lining with a coiled wrought-iron tube inserted from the muzzle.

The board on heavy rifled ordnance, instituted by the War Department under the act of Congress of June 6, 1872, for the selection of breech-loading and muzzle-loading rifled ordnance for experiments and tests, recommended, among other experiments, as follows:

"That in order to test the system of gun-conversions by lining with wrought iron or steel tubes, (as brought to the notice of the board in a communication addressed to the Chief of Ordnance by Maj. S. Crispin, and referred to the board by the Ordnance Department,) that four 10-inch smooth-bore Rodman guns be converted to muzzle-loading rifles, using two calibers, two of the guns to have a caliber of not less than 8 inches, and two to have a caliber of not less than 9 inches; and, further, that two of the guns be converted by tubing from the rear, and two by tubing from the front; the character of the metal lining, whether of steel or wrought iron, and other details of conversion, to be determined by the War Department."

The principal consideration which induced the board to recommend these tests are found, it is believed, in the following extracts from a communication addressed by Maj. S. Crispin to the Chief of Ordnance under date of June 12, 1872:

"In recent interviews with some of the members of the permanent board of engineers of the United States Army, my attention has been forcibly called to the subject of the utilization of our existing granite casemate sea-coast defenses by the replacement of their present smooth-bore armament and the introduction of rifled guns of the higher power which these works, from their capacity, will admit of being applied, and which armament will also be of adequate power for many other positions not needing our heavier calibers of 10 and 12 inch rifles.

"The enormous cost of these works, and the necessity of their utilization by the introduction of an armament not too bulky for their construction—effective against iron-clads as at present constructed—to replace their present low power, 8 and 10 inch smooth-bores, and other, and motives of economy should lead, in my judgment, to experiments with a view of determining if conversion (already successfully inaugurated in the English service) of our cast-iron smooth-bores to rifles of greatly increased power cannot be satisfactorily made in our service, thus utilizing both guns and casemates.

"The recommendations of the armament board of 1867, restricting our calibers to 10 and 12 inches for rifles, provide only for works of a capacity for their introduction; but as rifled ordnance, at least as low as 8 inches, can be effectually used against iron-clads, this question of utilization of existing works inadequate for our standard calibers receives additional importance. Considering that General Rodman, in his plans for heavy ordnance, contemplated an excess of strength for practical use, and knowing that England has already converted over five hundred 71-hundred-weight smooth-bores, and has one hundred more now under way at Elswick, (*prima-facie* evidence of success,) it would seem that we would be warranted in undertaking the experiment of the conversion of a 10-inch smooth-bore Rodman gun to a rifle of a caliber of either, say, 8 or 8½ inches, the exact caliber to be determined by a thorough examination and consideration of data, and the formation of a mature judgment as to what should be the maximum bore, consistent with a safe and durable converted gun.

"The general principles of conversion proposed—the lining of the bore with a tube—it will be remembered, was proposed for 10 and 12 inch experimental rfles by the ordnance board of 1868.

"The experiment preliminary to those proposed by the board of 1868, to line a 10-inch and 12-inch rifle, would at a moderate cost throw considerable light upon this subject, and is another reason for its being undertaken."

The decision of the board on heavy rifled ordnance in this regard having been approved, two 10-inch smooth-bore cast-iron Rodman guns have been converted, by lining them with wrought-iron coiled tubes inserted at the muzzle, one to an 8-inch rifle and the other to a 9-inch rifle, and were placed at the disposal of the board on experimental guns, &c., by the Chief of Ordnance, under date of October 22, 1874, and with instructions to fire 500 rounds, as contemplated by the board on rifling and venting, &c., convened under orders of the Department under date of March 29, 1873.

Five hundred and thirteen rounds have been fired from the 8-inch rifle so converted, up to the date of this report, under the supervision of the board.

GUNS.

Description of the 8-*inch gun.* (Plate.)

The gun is essentially composed of two parts, the original 10-inch smooth-bore bored up to an interior diameter of 13.5 inches, and a lining-tube of coiled wrought-iron, (welded,) the breech of which to a distance of 32.5 inches being a double tube, the outer one shrunk on to the inner, the former, however, having the same exterior diameter as the inner tube at the muzzle-end. (See plate.) A screw-collar, B, prevents the tube from being thrust forward at the muzzle by the compression of its metal by repeated firings. The bottom of the tube is closed by a wrought-iron base or cup.

The dimensions of the finished bore of the cast-iron body and the exterior dimensions of the inserted wrought-iron tube are given in the accompanying table, No. 3. It will be seen that play between the cast-iron body and the tube does not exceed 0.0105 inch for a length of 32 inches at the breech-end, and 0.009 inch for the remainder of its length. The tube was adjusted to the cast-iron body with great care, especially to insure its breech-end being closely in contact with the cast-iron. After its insertion, it was secured at the muzzle by the screw-collar above mentioned. The venting is the ordinary copper-bushing, the old vent being closed by a wrought-iron screw-plug.

A screw-plug, C, is inserted to prevent the tube from turning.

The rifling consists of 15 grooves and lands, (equal,) with a uniform twist of one turn in 40 feet. Additional details will be found in the drawing.

The weight of the gun and tube complete is 16,160 pounds.

CARRIAGE.

The gun is mounted on the ordinary service 10-inch wrought-iron carriage for the service of our 10-inch smooth-bore cannon in casemate. It consists of the upper carriage and chassis, the total weight being about 6,000 pounds. The axis of the gun is 7 feet above the surface of its wooden platform.

The upper carriage, consisting of two cheek-pieces connected by its transoms, has attached the box, clamp, and friction-plates of the recoil-check.

The only changes in its construction are the ones necessitated by the modes adopted for checking recoil and elevating and depressing the gun.

The following descriptions set forth these changes:

The recoil is checked by friction, using a special device. The principle of this check is as follows:

"The simple friction of two small plates, acting in contact with the upper and lower surfaces of a single broad wrought-iron rail, extending midway between the chassis-rails nearly the length of the carriage, combined with the increased resistance afforded by a slight wedge-shape given to the latter, afford the power for absorbing the recoil.

"This apparatus is secured to the front of the chassis by a transom, taking the place and position of the front hurters, and a plate bolted to it on top, between which the friction-rail passes, and *is free to move to the front longitudinally.* * * * It is secured at the rear end by a rod attached to a rubber or steel spring. When the recoil of the upper carriage ceases, the strain on the 'friction-rail' is at end; but the elasticity of the 'rail' reacts, and if it was rigidly attached at either end, a tendency to *buckle* would evidently exist and destroy it as a recoil-check. This was a serious imperfection in the smooth multirail compressor. This defect does not exist in the present arrangement. The front end of the 'rail' is free to move to the front, both because it is not rigidly fastened to the front hurter-transom of the chassis, and has a flexible attachment at the other or rear end, afforded by the rubber or steel spring.

"It is believed that by permanently attaching the box-clamp to the upper carriage and employing a simple automatic device to turn the screw through a given arc, and acting at the time when the upper carriage is into battery, a decided improvement will result; especially will this provide for any neglect of gunners to tighten the clamp before firing, and thus avoid the possibility of the check ever being in a condition not to act when the gun is fired."

For elevating and depressing, two circular-toothed arcs, having their centers at the axis of the trunnion, (one on each side,) are attached to the gun. A wrought-iron axle passing through the cheek-plates has at one end a hand-wheel. By simple multiplied gearing, power is transmitted to the toothed segments. This arrangement admits of 30 degrees of elevation and 14 degrees of depression.*

The means for loading and running the gun and carriage in and out of battery and traversing remain unchanged from the original system of 10-inch smooth bore carriages.

The ordinary service-pintle and strengthened pintle-transoms (2 inches thick) were used in the experiments.

PLATFORM.

The details of the wooden platform used need not here be described.

The carriage, complete, weighs about 6,000 pounds; the upper carriage weighs 2,500 pounds, and the chassis 3,500 pounds.

POWDER.

The experiments at Fort Monroe during the winter of 1872 and spring of 1873, with what is known as hexagonal-grained powder, manufactured by Messrs. E. I. Du Pont & Co., Wilmington, Del., demonstrated the superiority of this powder for heavy ordnance, giving low maximum pressures and satisfactory velocities, with great uniformity in its action. One of the samples tested, designated by the manufacturers as E. V., was selected as the standard for guns of 8 and 9 inch calibers.†

The uniformity in size of grain and their particular polyhedral shape insures great uniformity in the position and size of the numerous interstices in the make-up of the charges, and thus insures, with an uniformity of density in grain, a high degree of uniformity in pressures and velocities for given charges of powder and weights of projectiles.

The above is confirmed, it is believed, by the results shown in Table No. 1 of this report.

The powder used in the experiments was composed of the United States standard proportions for its different ingredients, and had a specific gravity of 1.7511. Its shape and dimensions of grains are given in the accompanying cut.

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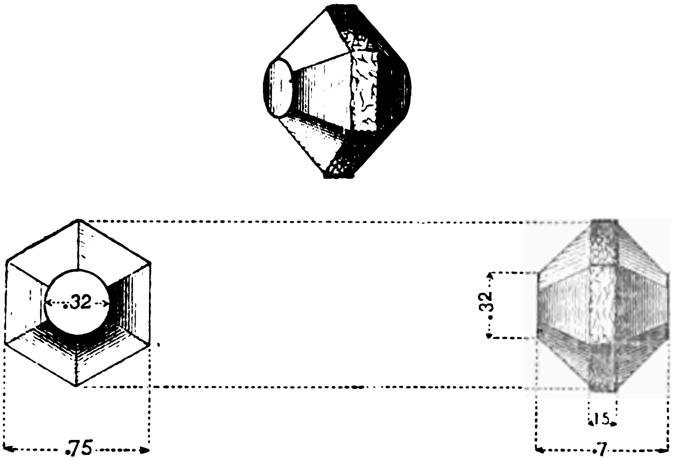
* This arrangement was only used during the last rounds.

† Fourteen charges, with 100 pounds of E. V. hexagonal-grained powder and 450-pound shot in the 15-inch gun, gave a mean maximum pressure of 18,964 pounds and a mean initial velocity of 1,594 feet. Three charges, using 120 pounds E. V. hexagonal-grained powder and 450-pound shot, gave a mean maximum pressure of 22,000 pounds and a mean initial velocity of 1,696 feet.

One 450-pound shot, with 125 pounds charge, gave a maximum pressure and velocity, the former 22,000 pounds and the latter 1,735 feet.

Seven rounds from an 8-inch wrought-iron rifle, with 35-pound charge, and an average weight of projectile of 168¾ pounds, gave a mean maximum pressure of 29,714 pounds and a mean initial velocity of 1,470 feet.



The cartridge-bags were made allowing a windage of .85 inch, the material used being woolen serge.

The friction-primers were made at Frankford Arsenal, and proved of excellent quality.

PROJECTILES.

The projectiles used in the experiments were elongated, cast-iron cored shot, with soft-metal bases, to take the grooves and insure rotation.

Two kinds were employed, (Butler and Arrick;) see Table No. 1. Their description will be found on the accompanying plate.

It will be seen (Tables Nos. 1 and 2) that 497 Butler and 16 Arrick were fired during the trials.* The shapes and general characteristics are shown in the plate.

The weights used will be found in Table No. 1.

The Butler projectile worked smoothly and uniformly, fully taking the grooves,† and giving general satisfaction.

EXPERIMENTS AND TESTS.

Trials were first made with charges of powder varying from 20 to 30 pounds, and with projectiles varying from 157 to 173 pounds, to note resulting pressures and velocities and the effects on the gun, and were preliminary to the use of 35-pound charges, the weight selected for the test of the gun for endurance. A record of these firings is given in Table No. 2. Satisfactory results having been attained, (see Table No. 2,) experiments were then commenced for testing the endurance of the gun, using 35-pound charges. Four hundred and ninety-eight rounds were fired with this charge, and six rounds with a charge of 30 pounds, completing a record of five hundred and four rounds.

The results of these firings are given in Table No. 1.

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*Firings were suspended with the Arrick projectiles after the sixteenth round—the lot of fifty presented for experiments and tests being judged by the board, in view of the results obtained with the sixteen rounds fired, as too imperfect to warrant further trials with them. It has since been reported to the board that the details of this projectile have been modified in some respects, and that the results with it were more satisfactory.

†The majority of these shot were recovered and examined.

It will be seen that five hundred and thirteen rounds in all have been fired from the gun. The velocities were taken with the Le Boulengé chronograph. The Rodman pressure-plug, placed in the cartridge-bag, was used for ascertaining the maximum pressures.

The calculated energy of a mean weight of projectile of 173.7 pounds, with 35 pounds charge, shows a power about equal to the wrought-iron, 8-inch, English service-rifle; and as it was believed that the length of the bore would enable us to economically burn but little, if any, more powder, a charge of 35 pounds was fixed as a maximum in the tests.

The mean maximum pressure with battering-charges, it will be seen, was 31,282 pounds.

The necessary repairs of proof-butt, the delays in the procurement of projectiles, &c., and the limited and imperfect character of our facilities at command, are causes which prevented an earlier completion of these experiments than December 23, 1874.

The gun was, as a rule, washed out, star-gauged, and examined at the end of each day's firing.

ACCURACY.

Before concluding the series of 513 rounds it was desired to make some experiments to test the accuracy of the systems of rifling and projectiles. Accordingly a board target, 20 by 40 feet, was erected, exactly one mile (1,760 yards) from the gun; and, commencing with the four hundred and sixty-sixth round, on December 22, 1874, thirteen consecutive shots, using 35-pound charges, were placed in the target, thus concluding the record of that day's firing.

The details of this firing are given in Table No. 7, and the accompanying target-plotting shows the accuracy attained.

Considering the appliances used for laying, training, sighting, and pointing the gun, and other circumstances attending the trial, this record must be considered highly satisfactory.

The remarkably small horizontal deviation affords indisputable evidence of the serviceable condition and good character of the rifling, and of the satisfactory action and accuracy of the projectiles.

EFFECTS ON THE GUN.

The attached table of enlargements (see Table No. 4) shows as follows:

After the first five rounds the star-gauging indicated no sensible enlargement of the bore; showing that the play allowed in the construction, between the tube and cast iron body, had not yet been obliterated, and that the tube was not yet set out firmly against the cast-iron walls. Seven additional charges, using battering-charges, firmly set the tube in its position.

The enlargements by subsequent firings are given in the table, and it will be seen, after 513 rounds, the maximum increase of bore was 0.0400 inch, and at 22 inches from bottom.

By deducting the play of the tube at that point, we have only an actual maximum enlargement, due to the total 513 rounds, of 0.0295 inch.

These results are especially satisfactory, as an official report of European experiments with converted systems (8-inch rifle) gave, in one case brought to the notice of the board, a maximum enlargement, after only 160 odd rounds, with 150-pound projectile and 30 pounds of powder, of 0.0600 inch.

Impressions of the bore taken with gutta-percha show but little erosion from the gases, and this, and a slight general roughness at the seat of the shot, is the extent of the damage done to the surface of the bore in the entire experiments and tests.*

This absence is only to be explained by the action of the soft-metal base of the projectile, which, before the inertia of the shot is overcome, is pressed against the lands and fills the grooves, thus diminishing the normal windage to a minimum, and preventing the flow of the gases over the body of the projectile.

Erosion is a prominent difficulty to be overcome, using non-expansion systems of projectiles for muzzle-loading rifles, and while their use may reduce the pressure to a slight extent in comparison with the systems tried by us, yet the absence of guttering, and other deteriorations of the bore, insured by the expanding systems, without abnormal or dangerous pressures, is highly satisfactory.

The vent shows a maximum enlargement of 24 inches, and a slightly-circular guttering exists at the exterior surface of the bushing at the surface of the bore. Some unimportant weld-marks are discernible on the bore.

In other regards the gun is in wholly sound condition, and is regarded by the board as perfectly serviceable for any desired additional experiments and tests.

EFFECTS ON CARRIAGE.

During the course of the trials numerous small repairs, such as replacement of bolts, &c., had to be made on the carriage, but no injuries requiring extensive overhauling occurred, and at the end of the trials its condition was one of general serviceability.

The "recoil check" performed its work well, and remained serviceable to the end of the firing.

The elevating-apparatus worked satisfactorily in its limited use, and may, it is believed, be relied upon for elevating and depressing, and to correct the effects of muzzle preponderance.

The mean recoils of the upper carriage will be found noted in Table No. 1.

The gun was served with the ordinary means and appliances provided for our 10-inch smooth-bores. It was mounted on a wooden platform, covered by a wooden casemate, for convenience in conducting the firings.

VELOCITIES AND PRESSURES.

An analysis of the record shows as follows:

A mean initial velocity of 1,374 feet, using battering-charges of 35 pounds powder, and a shot of 186 pounds, the mean maximum pressure being 33,583 pounds per square inch, and for a shot of 171 pounds a velocity of 1,419 feet, and a corresponding mean maximum pressure of 30,126 pounds. Seventy-eight shots of about the weight of the former, and 405 shots of about the weight of the latter, were fired.

The mean weight of all projectiles using 35-pound charges is 173.7 pounds, and the mean velocities and pressures obtained are respectively 1,411 feet and 31,300 pounds.

The record of firing, from which Table No. 1 was compiled, shows, taking into consideration variations in the manufacture of different lots of powder, a great uniformity in pressures for different weights of projectiles, and a perfectly satisfactory accord between pressures and corresponding initial velocities, giving convincing proof of uniformity in both the action of the powder and projectiles.

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* English official reports state that 180 rounds is the greatest number fired from any one gun, (80-pound converted,) without any injury.

STRENGTH OF THE SYSTEM.

The work performed by this system of gun-construction in these experiments and tests, it will be seen from the accompanying records, about equals that attained by the 8-inch wrought-iron rifle of the English service. The intention is to secure from our 10-inch smooth-bore system, by conversion, a rifle of at least the power attained in these experiments, and of sufficient strength to guarantee an adequate endurance for the number of rounds which may be deemed necessary the system should stand.

The principal dimensions of the 10 inch smooth-bore gun are, a total length of 136.66 inches, a length of bore of 120 inches, a maximum diameter of 32 inches, a thickness at the breech of 16 inches, and a diameter at the muzzle of 16.2 inches.

As converted on the present plan to an 8-inch rifle, (16,160 pounds weight,) we have a thickness at the breech of 19 inches, a thickness of walls at the maximum diameter of 12 inches, and at the muzzle of 4.1 inches, and a length of bore of 117.25 inches. It closely approximates in these dimensions to the Woolwich 8-inch gun of 9 tons. This latter system is evidently one of great strength *per se;* but, in the opinion of the board, in this regard it is more than equal to the work required of it—using improved powders giving reduced pressures.

The fact that R. L. G. English powders give maximum pressures of 29.8 tons per square inch, whereas pebble or hexagonal powders reach only a maximum pressure of about 15 tons per square inch, (all these kinds were used in 8-inch rifles, employing the same weight of charge and projectile,) shows the important changes which have been made in powders as to pressures—velocities being maintained—and points to the conclusion that gun-constructions lighter in weight, and not so strong in material as the English system, can be successfully used to obtain the same power and still have an adequate endurance. The fact that a gun is strong enough to withstand R. L. G. powder, or its equivalent, is not so important in our land service with heavy ordnance, as there exists no adequate reasons to fear the contingency of the absence under any circumstances for service with our guns of supplies of large grain or hexagonal powders, or powders possessing their characteristics.

The special construction tested, the subject of this report, in the use of battering-charges, had to endure maximum strains (repeated) of say 31,300 pounds per square inch at the surface of the bore. This would give a strain of say 11,000 pounds per square inch in a homogeneous structure on that circumference which is now the interior surface of the cast-iron body.

Even making a considerable allowance for the more compressible nature of wrought iron over cast iron, it is fair to presume that the cast-iron body, at the surface of its bore, had not to endure, in the five hundred and odd rounds fired, at any fire over one-half of its tensile strength, (30,000 pounds,) and hence the inference is warranted that cast iron is entirely adequate to perform the work which would be required of it in resisting tangential strains in 8-inch converted guns, constructed as the one tested, using thickness of tube of 2.75 inches.

Another inference to be drawn from these experiments and the above views is, that it is probable, with our superior production of cast iron in this country, using the principles of hollow castings and interior coolings, and a strong and judicious mode of lining the gun, either steel or wrought iron, that new constructions, applicable to rifles of 10 and 12 inch and even higher calibers, and having the necessary strength and endurance and uniformity of endurance required for all the wants and vicissitudes of our sea-coast service, can be economically secured; also, if deemed desirable, that our 15-inch guns can probably be converted into durable rifles, having a large increase over their present powers.

In this connection it may be noted that it is thought beyond question that built-up gun-constructions (rifles,) using either steel or wrought-iron tubes for the interior and cast iron for the body, are superior in strength (and no liability to *explosive bursting*) to homogeneous structures composed entirely of cast iron, and hence, that the converted systems proposed will have greater endurance than similarly-modeled 8-inch cast-iron rifles. It is also believed that built-up gun-constructions, with proper kinds and qualities of metals for the interior tubes and the exterior bodies, have a broader margin of safety from the separation into parts, in the cases of excessive or long-continued strains, than homogeneous structures made in one solid mass and finished from such masses. It is inferred from the above considerations and the satisfactory results attained in our trials, that a durable rifle of at least 8-inch caliber, to use full battering-charges, can be secured by conversion on the plan tested. While expressing confidence in this plan from the results attained, yet the board deems it important to call attention to the fact that more endurance may be obtained by other systems of conversion, equally as economical, now in course of preparation for test and experiment.

EFFECTS AGAINST ARMOR-PLATES.

The table of comparisons between the 8-inch converted and the English 8-inch 9-ton gun, shows that we can calculate on a power from the former equal to that of the latter. (See table No. 5.)

The calculations are not carried beyond 1,800 yards, as, at our more important harbor-defenses, a greater range than this would not generally be required for their casemated guns, which would probably be used in case of attack as powerful auxiliaries to the larger calibers of 10 and 12 inch rifles.

The calculated power against armor-plates (unbacked) is at the muzzle, a penetration of 8.66 inches; at 600 yards, 7.87 inches; at 1,000 yards, 7.42 inches; and at 1,800 yards, 6.75 inches.

It is believed that in some of our harbors where the draught of water is comparatively light, guns of this power would have sufficient energy to afford by themselves an efficient armament.

It may be here stated that the nationalities of Europe embrace in their calibers for heavy ordnance as low as 7 inches.

Table No. 6 shows that an increase in power from two to three fold over the original smooth-bore 10-inch gun, at ranges varying from 1,000 to 3,000 yards, is gained by the conversion.

RECOMMENDATIONS OF THE BOARD.

The present armament for our sea-coast includes for our casemate defenses 1,294 10-inch Rodman smooth-bore guns, distributed in our harbors as follows: At Portland, Me.; Boston and New Bedford, Mass.;

Newport, R. I.; New York, N. Y.; Fort Delaware, Del.; Hampton Roads, Va.; Charleston and Savannah Harbors; the forts of the Gulf; and the harbor of San Francisco, Cal.

These guns are worthless for the purposes of defense against armor-plated vessels of modern construction; and the casemates provided for their emplacements (which have cost millions of money) are now useless, and demand for their utilization either a re-armament of new guns, or that the old ones shall be converted into rifles of efficient power to render the casemate-batteries powerful and efficient auxiliaries to our heavier calibers *en barbette;* all to provide effective harbor-defenses.

Proof that effective and durable guns can be provided by conversion having been given by our recent experiments, and conversion affording an undoubted economy, it is recommended that the Department ask for liberal appropriations to be made to initiate the work of providing converted rifles for already existing permanent casemated works now useless, as above stated, for the want of efficient armaments, yet for which appropriations are annually being made.

The strong assurances offered by our experiments, that additional experimental guns of the heaviest caliber now fabricated by civilized nations constructed on the principle of combining cast-iron with wrought-iron or steel lining-tubes, and after judicious and well-authenticated and matured plans, approved by the Department, will, when tested, give successful results, and prove that an effective, durable, and economical rifle-armament can be secured, leads the board to submit the additional recommendation that Congress be asked to appropriate an adequate sum for further experiments and tests, and especially for the manufacture, trial, and tests of one 10 and one 12 inch experimental rifle, to be constructed in accordance with the general plan above suggested.

S. CRISPIN,
Bvt. Col. U. S. A., Maj. of Ordnance, President of Board.
T. J. TREADWELL,
Major of Ordnance.
T. G. BAYLOR,
Major of Ordnance.
GEO. W. McKEE,
Captain of Ordnance, Recorder of Board.

Respectfully submitted to the Secretary of War.

S. V. BENÉT,
Brig. General, Chief of Ordnance.

TABLE No. 1.—*Record of firings for endurance with an 8-inch experimental rifle, from October 24 to December 23, (inclusive,) 1874, at Sandy Hook, N. J.*

Description of gun.	Dates.	Number of shots.	Kinds of powder.	CHARGE. Cartridge. Weight.	CHARGE. Cartridge. Height.	CHARGE. Diameter.	PROJECTILE. Kind.	PROJECTILE. Weight.	PROJECTILE. Length.	PROJECTILE. Diameter.	Mean observed velocities of the projectile at 110 feet from the muzzle of the gun, as recorded by Le Boulengé's chronograph.	Velocities at the muzzle.	ENERGY OF PROJECTILE. Total at the muzzle. $\frac{P\ V^2}{2g}$	ENERGY OF PROJECTILE. Per inch of the shot's circumference. $\frac{P\ V^2}{2g\,2KR}$	Gas-pressure per square inch of surface of bore, as taken with Rodman's internal-pressure gauge.	Recoil of upper carriage.	Remarks.
	1874.			*Lbs.*	*In*	*In.*		*Lbs.*		*In.*	*Feet.*	*Feet.*	*Foot-lbs.*	*Foot-lbs.*	*Lbs.*	*Ft.*	
GUN No. 1.—A rifle, converted from a 10-inch Rodman cast-iron smooth-bore, by lining with a jacketed wrought-iron coiled tube inserted at the muzzle; caliber, 8 inches; total length of gun, 136.66 inches; length of bore, 117.25 inches; length of rifling, 107.25 inches; diameter of bore, including grooves, 8.15 inches; number of grooves and lands, 15 each; twist uniform; one turn in 40 feet. Weight of gun, 16,160 pounds.	From October 24 to 28, inclusive.	2	Dupont's Hexagonal E. V. (1874) density, 7.511.*	35	22	7.15	†Butler.	160	18	7.95	1,449	1,459	5,288.648	211.546	34.225	3.99	Distance of the first wire target from muzzle of the gun, 60 feet; distance between first and second targets, 100 feet. Mean weight of projectiles, using battering-charges, (35 pounds,) 173.70 pounds; mean velocity at muzzle, using battering-charges, (35 pounds,) 1,411 feet; mean maximum pressure, using battering-charges, (35 pounds.) 31.282 pounds; mean energy at muzzle, using battering-charges, (35 pounds,) 5,369.947 pounds. The maximum velocity at the muzzle, obtained with 35 pounds of powder and 165-pound projectile, 1,422 feet; maximum velocity at muzzle, with 35 pounds of powder and 170-pound projectile, 1,440 feet; maximum velocity at muzzle, with 35 pounds of powder and 174-pound projectile, 1,420 feet; and with 35 pounds powder and 187-pound projectile, 1,380 feet. Mean recoil of upper carriage, 3.79 feet. Butt, 200 feet from muzzle of the gun. N. B.—Four hundred and seventy-nine (479) shots were fired into the butt, distant 200 feet from the muzzle of the gun; 13 into a target, 20 by 40 feet, at the distance of one mile from the gun; and 12 others, for tests of flight over water, &c. *a*. These charges are exceptional, and were
		9		35	22	7.15	..do ...	173	18	7.95	1,423	1,432	5,508.664	220.346	32.278	3.67	
		25		35	22	7.15	..do ...	186	19	7.95	1,357	1,365	5,381.364	215.254	33.833	4.39	
		2		*a*30	22	7.15	..do ...	186	19	7.95	1,296	1,303	....	....	....	....	
	From October 29 to 30, inclusive.	3		35	22	7.15	..do ...	186	19	7.95	1,368	1,376	5,468.446	218.737	32.666	4.4	
		12		35	22	7.15	*Arrick	165	19	7.95	1,413	1,422	5,180.806	207.232	33.333	3.53	
	On October 29 and November 6.	4		*a*30	22	7.15	..do ...	165	19	7.95	1,352	1,361	....	......	....	....	
	On November 16 ..	14		35	22	7.15	Butler.	174	18	7.95	1,411	1,420	5,448.037	217.921	31.714	4.15	
	On November 17 ..	37		35	22	7.15	..do ...	173.9	18	7.95	1,402	1,412	5,383.727	215.349	34.000	3.71	
		19		35	22	7.15	..do ...	186.2	19	7.95	1,366	1,375	5,466.372	218.654	34.000	3.85	
	On November 18.	31		35	22	7.15	..do ...	187	19	7.95	1,372	1,380	5,616.969	214.678	33.500	3.51	
	From November 21 to November 27.	36		35	22	7.15	..do ...	170.27	18	7.95	1,417	1,426	5,376.396	215.055	30.708	3.73	
	On November 27 and November 28.	33		35	22	7.15	..do ...	170.6	18	7.95	1,411	1,420	5,341.581	213.663	28.525	4.12	
	From December 1 to December 3, inclusive.	24		35	22	7.15	..do ...	170.2	18	7.95	1,417	1,426	5,374.186	214.967	29.875	2.80	
	On December 9 and December 10.	50		35	22	7.15	..do ...	170.38	18	7.95	1,396	1,405	5,222,583	208.903	26.214	3.35	
	From December 12 to December 14, inclusive.	50		35	22	7.15	..do ...	170.25	18	7.95	1,385	1,394	5,137.203	205.488	27.214	3.28	
	From December 15 to December 17, inclusive.	51		35	22	7.15	..do ...	171	16	7.95	1,386	1,395	5,159.274	206.370	28.7000	3.58	

TABLE No. 1.—*Record of firings for endurance with an 8-inch experimental rifle, &c.*—Continued.

Description of gun.	Dates.	Number of shots.	CHARGE.				PROJECTILE.				Mean observed velocities of the projectile at 110 feet from the muzzle of the gun, as recorded by Le Boulengé's chronograph.	Velocities at the muzzle.	ENERGY OF PROJECTILE.		Gas-pressure per square inch of surface of bore, as taken with Rodman's internal-pressure gauge.	Recoil of upper carriage.	Remarks.
			Kinds of powder.	Cartridge. Weight.	Cartridge. Height.	Diameter.	Kind.	Weight.	Length.	Diameter.			Total at the muzzle. $\frac{P V^2}{2 g}$	Per inch of the shot's circumference. $\frac{P V^2}{2\pi 2 K R}$			
	1874			*Lbs.*	*In*	*In.*		*Lbs.*		*In.*	*Feet.*	*Feet.*	*Foot-lbs.*	*Foot-lbs.*	*Lbs.*	*Ft.*	
	On December 18 ..	34		35	22	7.15	..do ...	171.64	16	7.95	1,400	1,410	5,298.718	211.948	32.625	3.78	used for experiments with projectiles, &c.
	On December 21 and December 22.	36		35	22	7.15	..do ...	171.25	16	7.95	1,435	1,444	5,532.291	221.291	31.500	3.82	
	On December 23 ..	32		35	22	7.15	..do ...	170	16	7	1,431	1,440	5,473.788	218.951	28.166	3.52	
		504															

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* For further description see accompanying plate and report.

† For description of projectiles see accompanying reports and drawings.

Board on experimental guns, &c., convened under orders of the War Department dated October 10, 1874.

GEO. W. McKEE,
Captain of Ordnance, Recorder.

TABLE No. 2.—*Records of firings with an eight-inch experimental rifle, on October 23 and October 24, 1874, at Sandy Hook, N. J.*

Description of gun.	Dates.	Number of shots.	CHARGE.				PROJECTILE.				Velocities.	Pressures.	Remarks.
			Kind of powder.	Weight.	Cartridge.		Kind.	Weight.	Length.	Diameter.			
					Height.	Diameter.							
	1874.			*Lbs.*	*Ins.*	*Ins.*		*Lbs.*	*Ins.*	*Ins.*	*Feet.*	*Pounds.*	
GUN No. 1.—Weight, 16,160 pounds; a rifle, converted from a 10-inch Rodman cast-iron smooth-bore, by lining with a jacketed wrought-iron coiled tube, inserted from the front or muzzle; caliber, 8 inches; total length of gun, 136.66 inches; length of bore, 117.25 inches; length of rifling, 107.25 inches; diameter of bore, including grooves, 8.15 inches; number of grooves and lands, 15 each; twist uniform, one turn in 40 feet.	October 23	1	Dupont's hexagonal E. V., (1874.) Density, 1.7511.	20	15.5	7.15	Butler.	157	18	7.95	Omitted.	Omitted.	Distance from muzzle of the gun to the first wire target, 60 feet; distance between wire targets, 100 feet; distance from muzzle of the gun to butt, 200 feet. All these shots were fired into the butt, and were preliminary to the 504 rounds fired afterward, to test the endurance of the gun.
	October 23	2		20	12.5	7.15	..do ...	160	18	7.95	1,015	12,500	
	October 23	3		25	15.6	7.15	..do ...	173	18	7.95	1,273	30,000	
	October 23	4		25	15.6	7.15	..do ...	173	18	7.95	1,265	35,000	
	October 23	5		25	15.6	7.15	..do ...	173	18	7.95	1,237	30,000	
	October 24	6		30	19.7	7.15	..do ...	160	18	7.95	1,381	32,500	
	October 24	7		30	19.7	7.15	..do ...	160	18	7.95	1,375	36,000	
	October 24	8		30	19.7	7.15	..do ...	173	18	7.95	1,330	27,500	
	October 24	9		30	19.7	7.15	..do ...	173	18	7.95	1,349	36,000	

Board on experimental guns, &c., convened under orders of the War Department dated October 10, 1874.

GEO. W. McKEE,
Captain of Ordnance, Recorder.

TABLE No 3.—*Relative diameters of bore of cast-iron body of 10-inch gun and wrought-iron tube for insertion therein at different points of their cylindrical length.*

Inches from face of muzzle.	Interior diameters of bore.	Exterior diameters of tube.	Inches from face of muzzle.	Interior diameters of bore.	Exterior diameters of tube.	Inches from face of muzzle.	Interior diameters of bore.	Exterior diameters of tube.
118	13.4965	13.4860	91	13.4965	13.4860	48	13.4955	13.4860
117	13.4965	13.4860	90	13.4965	13.4860	46	13.4955	13.4860
116	13.4965	13.4860	89	13.4965	13.4860	44	13.4955	13.4860
115	13.4965	13.4860	88	13.4965	13.4860	42	13.4955	13.4860
114	13.4965	13.4860	87	13.4965	13.4860	40	13.4955	13.4860
113	13.4965	13.4860	86	13.4965	13.4860	38	13.4955	13.4860
112	13.4965	13.4860	85	13.4965	13.4860	36	13.4955	13.4860
111	13.4965	13.4860	84	13.4965	13.4860	34	13.4955	13.4860
110	13.4965	13.4860	83	13.4965	13.4860	32	13.4955	13.4860
109	13.4965	13.4860	82	13.4965	13.4860	30	13.4955	13.4860
108	13.4965	13.4860	81	13.4965	13.4860	28	13.4955	13.4860
107	13.4965	13.4860	80	13.4965	13.4860	26	13.4955	13.4860
106	13.4965	13.4860	78	13.4965	13.4860	24	13.4955	13.4860
105	13.4965	13.4860	76	13.4965	13.4860	22	13.4955	13.4860
104	13.4965	13.4860	74	13.4965	13.4860	20	13.4955	13.4860
103	13.4965	13.4860	72	13.4960	13.4860	18	13.4955	13.4860
102	13.4965	13.4860	70	13.4955	13.4860	16	13.4955	13.4860
101	13.4965	13.4860	68	13.4955	13.4860	14	13.4955	13.4860
100	13.4965	13.4860	66	13.4955	13.4860	12	13.4955	13.4860
99	13.4965	13.4860	64	13.4955	13.4860	10	13.4955	13.4860
98	13.4965	13.4860	62	13.4955	13.4860	8	13.4955	13.4860
97	13.4965	13.4860	60	13.4955	13.4860	6	13.4955	13.4860
96	13.4965	13.4860	58	13.4955	13.4860	4	13.4955	13.4860
95	13.4965	13.4860	56	13.4955	13.4860	2	13.4955	13.4860
94	13.4965	13.4860	54	13.4955	13.4860	1	13.4955	13.4860
93	13.4965	13.4860	52	13.4955	13.4860			
92	13.4965	13.4860	50	13.4955	13.4860			

JOHN G. BUTLER,
Captain of Ordnance.

Board on experimental guns, &c., convened under orders of the War Department dated November 10, 1874.

GEO. W. McKEE,
Captain of Ordnance, Recorder.

TABLE No. 4.—*Table of enlargements of 8-inch converted rifle No. 1.*

Inches from bottom of bore.	Original play of tube.	Original diameter of bore.	Enlargement after 5 charges of 20 to 35 pounds.	A, after 12 rounds, (7 battering-charges.)	Enlargements from column A, (after setting up of tube.)					Total enlargement after 513 rounds, including the "set up" of tube.
					After a total of 100 rounds.	After a total of 203 rounds.	After a total of 310 rounds.	After a total of 411 rounds.	After a total of 513 rounds.	
11	0.0105	7.985	No enlargement of bore, tube not set out.	0.022	0.005	0.005	0.005	0.005	0.005	0.021
13	0.0105	7.985		0.020	0.005	0.005	0.005	0.005	0.005	0.027
16	0.0105	7.985		0.019	0.004	0.004	0.004	0.004	0.005	0.025
19	0.0105	7.985		0.019	0.006	0.006	0.006	0.007	0.008	0.024
22	0.0105	7.985		0.022	0 006	0.006	0.007	0.011	0.018	0.047
25	0.0105	7.985		0.020	0.007	0.008	0.009	0.012	0.016	0.030
28	0.0105	7.985		0.017	0.008	0.009	0.010	0.013	0.015	0.036
31	0.0105	7.985		0.003	0.009	0.010	0.011	0.013	0.015	0.022
34	0.0100	7.985		0.009	0.006	0.007	0.008	0.010	0.011	0.028
37	0.0100	7.985		0.007	0.004	0.004	0.005	0.007	0.008	0.010
40	0.0100	7.985		0.003	0.003	0.003	0.005	0.006	0.007	0.015
45	0.0100	7.985		0.002	0.002	0.002	0.003	0.004	0.005	0.000
50	0.0095	7.985		0.002	0.002	0.002	0.002	0.003	0.004	0.007
55	0.0095	7.985		0.001	0.001	0.001	0.001	0.002	0.003	0.006
60	0.0095	7.985		0.001	0.001	0.001	0.001	0.001	0.002	0.004
65	0.0095	7.985		0.001	0.000	0.000	0.000	0.001	0.002	0.003
70	0.0095	7.985		0.000	0.000	0.000	0.000	0.000	0.002	0.003
80	0.0095	7.985		0.000	0.000	0.000	0.000	0.000	0.001	0.002
90	0.0095	7.985		0.000	0.000	0.000	0.000	0.000	0.001	0.001
100	0.0095	7.985		0.000	0.000	0.000	0.000	0.000	0.001	0.001
118	0.0095	7.985		0.000	0.000	0.000	0.000	0.000	0.001	0.001

Board on experimental guns, &c., convened under orders of the War Department dated October 10, 1874.

GEORGE W. McKEE,
Captain of Ordnance, Recorder.

TABLE No. 5.—*Table comparing the relative energies of the 8-inch United States rifled muzzle-loader, converted, and the 8-inch English rifled muzzle-loader of 9 tons, to distances up to 1,800 yards.*

Range.	*8-inch rifled muzzle-loader of 9 tons; charge, 35 pounds; projectile, 180 pounds.			8-inch United States rifled muzzle-loader, converted, 16,200 pounds; charge, 35 pounds; projectile, 186.5 pounds.			Remarks.
	V.	Total energy.	Energy per inch of shot's circumference.	V.	Total energy.	Energy per inch of shot's circumference.	
Yards.	*Feet.*	*Foot-tons.*	*Foot-tons.*	*Feet.*	*Foot-tons.*	*Foot-tons.*	
0	1,413	2,492	100.2	1,374	2,441	97.7	78 shots were fired with the 186.5-pound projectile.
200	1,369	2,339	94.0	1,333	2,297	91.9	
400	1,327	2,198	88.3	1,295	2,123	85.0	
600	1,286	2,064	83.0	1,259	1,980	79.2	
800	1,248	1,944	78.1	1,224	1,957	78.3	
1,000	1,213	1,837	73.8	1,192	1,837	73.5	
1,200	1,180	1,738	69.9	1,161	1,742	69.7	
1,400	1,150	1,651	66.3	1,132	1,657	66.3	
1,600	1,122	1,571	63.2	1,104	1,576	63.1	
1,800	1,097	1,502	60.4	1,077	1,499	60.0	

* Compiled from English tables.

Board on experimental guns, &c., convened under orders of the War Department dated October 10, 1874.

GEO. W. McKEE,
Captain of Ordnance, Recorder.

TABLE No. 6.—*Relative effectiveness of a 10-inch smooth-bore, and the same gun converted into an 8-inch rifle.*

Gun.		Weight of shot.	Velocity at muzzle.	Energy at muzzle.	Penetration in backed armor plates.	Foot-tons per inch of shot circumference.				Relative accuracy.	Relative capacity of shell for bursting charge.
Kind.	Caliber.					At muzzle.	At 1,000 yards.	At 2,000 yards.	At 3,000 yards.		
		Pounds.	*Feet.*	*Foot-tons.*	*Inches.*						
Smooth-bore..........	10″	127	1600	2255	7.30	73	36	20	14	1	1
Rifle	8″	187	1375	2444	8.45	98	74	60	49	3	2

Board on experimental guns, &c., convened under orders of the War Department dated October 10, 1874.

GEO. W. McKEE,
Captain of Ordnance, Recorder.

TABLE No. 7.—*Record of target-firing with 8-inch converted rifle No. 1, at Sandy Hook, N. J., December 22, 1874.*

[Distance of the target from the muzzle, one mile.]

Number of fire.	Powder.		Projectile.		Elevation.	Deviation from center of target.				Deviation from center of impact.			
						Yards.				Yards.			
	Kind.	Weight.	Kind.	Weight.		Right.	Left.	Above.	Below.	Right.	Left.	Above.	Below.
					° ′								
466	Dupont's hexagonal.	35	Butler.	171	3 0	......	0.25	2.50	......	0.39	......	1.88	......
467		35		170	2 55	......	0.33	1.16	......	0.30	......	0.55	......
468		35		171	2 55	0.00	0.00	......	0.92	0.63	......	......	1.50
469		35		170	2 55	0.25	......	2.61	......	0.88	......	2.03	......
470		35		170	2 55	......	0.83	......	0.94	......	0.14	......	1.53
471		35		170	2 55	......	3.05	3.28	......	......	2.42	2.70	......
472		35		170	2 55	......	......	......	3.00	......	0.47	......	......
473		35		170	2 55	0.11	......	0.83	......	0.35	......	0.20	......
474		35		170	2 55	......	0.22	......	3.16	0.42	......	......	3.75
475		55		170	2 55	0.00	0.00	1.33	......	0.63	......	0.75	......
476		35		170	2 55*	......	......	......	......	......	......	......	......
477		35		170	2 55	......	0.33	3.08	......	0.30	......	2.50	......
478		35		170	2 55	......	0.83	......	0.86	......	0.14	......	1.44
479		35		170	2 55	......	1.83	1.66	......	......	1.20	1.08	......

* Fired into sand-butt.

REMARKS.

Kind of cannon, number, and when made—8-inch converted rifle from 10-inch Rodman No. 2,240.
Diameter of bore, 8-inch.
Weight of piece in pounds, 16,160.
Character of rifling, uniform, 15 grooves, one turn in 40 feet.
Kind of carriage, wrought iron, front pintle.
Height of axis of bore above plane on which projectile strikes, 7 feet.
Sound of projectile in flight, clear and smooth.
Weather—
  Thermometer, ——.
  Barometer, low.
  Atmosphere, damp.
Kind of pressure-plug, Rodman's internal.
Kind of Ballistic machine, Le Boulengé chronograph.
Strength and direction of wind, fresh, front, and left.

Plate. I.

10 INCH RODMAN S.B. GUN CONVERTED INTO AN 8 INCH M.L. RIFLE.

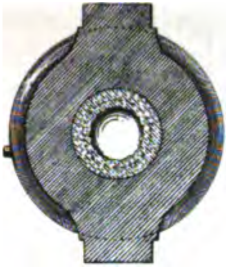


Fig. 4.

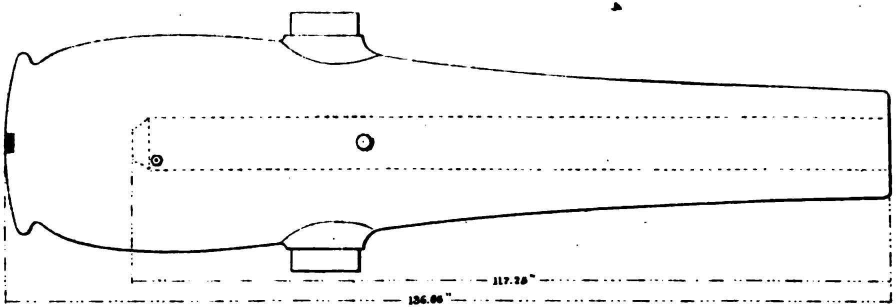


Fig. 1.

Board on Experimental Guns, etc., convened under orders of the War Department, dated October 10, 1874

Geo. W. McKee
Captain of Ordnance, Recorder.

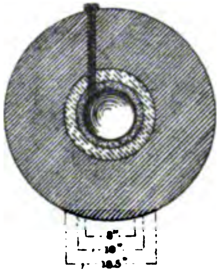


Fig. 5.

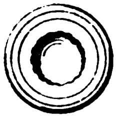


Fig. 3.

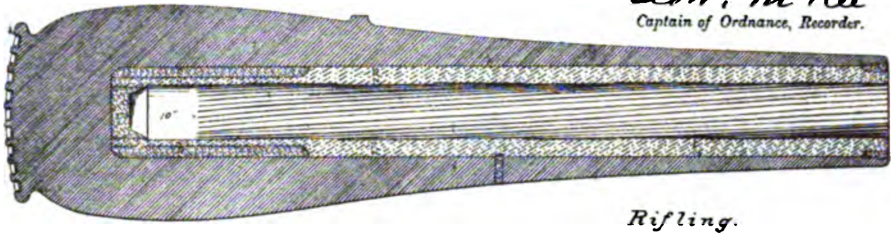
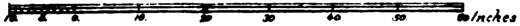


Fig. 2.

Scale.



Rifling.

Twist uniform, one turn in 40 feet.
15 Grooves and Lands, each 0.83772" wide.
Grooves 0.075" deep.
Weight 16160 lbs.

AM. PHOTO-LITHOGRAPHIC Co. N.Y. (OSBORNE'S PROCESS)

Plate III.

BUTLER — 187 LBS.

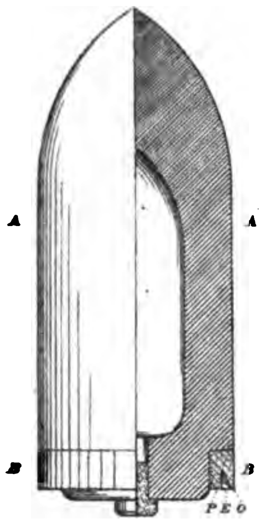
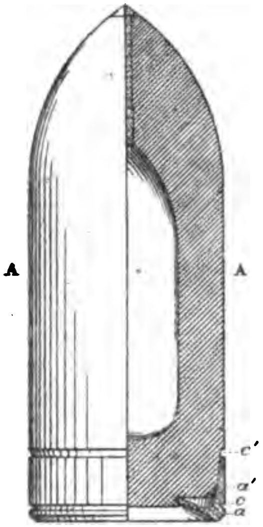


Plate IV.

ARRICK — 165 LBS.



Scale.

DESCRIPTION OF BUTLER PROJECTILE.

The Butler projectile consists of a cast-iron body, A, having a double-lipped ring of brass, B, attached by a screw-thread to its base. O is the upper lip, P the lower lip, and E the cannelure or annular groove between them. The following is claimed for the invention:

"The projectile being inserted without respect to the rifling, and the gun discharged, the powder gases are quickly and evenly distributed around the annular channel, and the upper lip is uniformly expanded into the grooves of the gun whereby the desired rotation is communicated to the projectile. While, however, the upper lip is expanded into the rifling, the lower lip is pressed upon the body of the projectile with an intensity proportionate to the force of discharge, thus not only causing the ring to hug the projectile tightly, but as a 'gas-check' preventing the entrance of gas between the ring and the iron body of the projectile. Stripping is thus effectually prevented. The rings may be variously attached. The advantage of attaching them by means of the screw-thread is that by unscrewing the old ring after firing and applying a new one, which may be made of the old material, the projectile can be fired several times into the proof-butt before being so far injured by sand scouring as to render it unfit for further use."

The double-lipped ring in the present instance is composed of seventy-five parts of copper and twenty-five parts of zinc. Its general features and dimensions are shown in the plate.

DESCRIPTION OF ARRICK PROJECTILE.

The Arrick projectile presented to the Board consists of the usual cast-iron body A, the base of which is a frustum of a cone having attached to it a sabot combined of an annular key, *a'*, and a concave and convex disk, *a*.

The following is claimed for the invention:

"The primary object of my (the) invention is the introduction at the base of a rifle projectile of an 'automatic check,' to be actuated by the force of the discharge *before the inertia of the projectile is overcome*, whereby the windage will be closed and the axis of the projectile be made to coincide with the axis of the piece from which it is fired. The arrangement is effected by combining with a concave and convex disk, a cylinder-key so adapted and applied to the base of the projectile, as to insure under the pressure of discharge, the *primary* effect sought, and at the same time guarantee that, as the projectile is driven out of the piece, it shall have imparted to it, by such disk, the motion of rotation essential to accuracy of flight."

"Under the pressure of the discharge the disk *a* is flattened against the base of the shot, so that what were its concave and convex surfaces are now plane surfaces, at right angles to the axis of the projectile and the bore of the gun, and its rim has received the impression of its lands and grooves. The metal composing the annular key *a'* has, at the same time, been pressed or driven forward into the space *c'* and has been caused to assume the *form of* and to occupy and fill, at a close metal fit with the *lands only*, the annular rabbet and the windage surrounding it, the key *a'* in its new form *chucking*, and its disk *a* being prepared to rotate the projectile; and this condition exists before the inertia of the projectile is overcome, so that as it is started from its bed the only frictional resistance to be overcome is the metal fit of the rim of the disk *a* with the entire surface of the lands and grooves and the outer surface of the key *a'* with the surface of the lands only.

"The friction of the key *a'* on the projectile, assisted by that of the disk pressing upon its base, will prevent any axial motion of the disk, not only guaranteeing the rotation of the projectile, but also with absolute certainty the retention in its place of the disk through its trajectory."

The general features and dimensions are shown in the plate. Board on Experimental Guns, etc., convened under orders of the War Department, dated October. 10, 1874

Geo. W. McKee

Captain of Ordnance, Recorder.

AM. PHOTO-LITHOGRAPHIC Co. N.Y. (OSBORNE'S PROCESS)

Plate III.

BUTLER — 187 LBS.

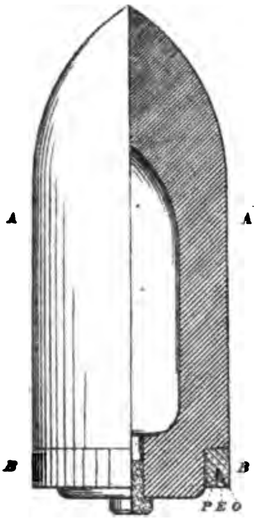
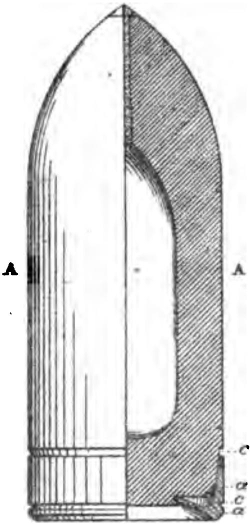


Plate IV.

ARRICK — 165 LBS.



Scale.

DESCRIPTION OF BUTLER PROJECTILE.

The Butler projectile consists of a cast-iron body, A, having a double-lipped ring of brass, B, attached by a screw-thread to its base. O is the upper lip, P the lower lip, and E the cannelure or annular groove between them. The following is claimed for the invention:

"The projectile being inserted without respect to the rifling, and the gun discharged, the powder gases are quickly and evenly distributed around the annular channel, and the upper lip is uniformly expanded into the grooves of the gun whereby the desired rotation is communicated to the projectile. While, however, the upper lip is expanded into the rifling, the lower lip is pressed upon the body of the projectile with an intensity proportionate to the force of discharge, thus not only causing the ring to hug the projectile tightly, but as a 'gas-check' preventing the entrance of gas between the ring and the iron body of the projectile. Stripping is thus effectually prevented. The rings may be variously attached. The advantage of attaching them by means of the screw-thread is that by unscrewing the old ring after firing and applying a new one, which may be made of the old material, the projectile can be fired several times into the proof-butt before being so far injured by sand scouring as to render it unfit for further use."

The double-lipped ring in the present instance is composed of seventy-five parts of copper and twenty-five parts of zinc. Its general features and dimensions are shown in the plate.

DESCRIPTION OF ARRICK PROJECTILE.

The Arrick projectile presented to the Board consists of the usual cast-iron body A, the base of which is a frustum of a cone having attached to it a sabot combined of an annular key, a′, and a concave and convex disk, a.

The following is claimed for the invention:

"The primary object of my (the) invention is the introduction at the base of a rifle projectile of an 'automatic chuck,' to be actuated by the force of the discharge *before the inertia of the projectile is overcome*, whereby the windage will be closed and the axis of the projectile be made to coincide with the axis of the piece from which it is fired. The arrangement is effected by combining with a concave and convex disk, a cylinder-key so adapted and applied to the base of the projectile, as to insure under the pressure of discharge, the *primary* effect sought, and at the same time guarantee that, as the projectile is driven out of the *piece*, it shall have imparted to it, by such disk, the motion of rotation essential to accuracy of flight."

"Under the pressure of the discharge the disk *a* is flattened against the base of the shot, so that what were its concave and convex surfaces are now plane surfaces, at right angles to the axis of the projectile and the bore of the gun, and its rim has received the impression of its lands and grooves. The metal composing the annular key *a′* has, at the same time, been pressed or driven forward into the space *c′* and has been caused to assume the *form of* and to occupy and fill, at a close metal fit with the *lands only*, the annular rabbet and the windage surrounding it, the key *a′* in its new form *chucking*, and its disk *a* being prepared to rotate the projectile; and this condition exists before the inertia of the projectile is overcome, so that as it is started from its bed the only frictional resistance to be overcome is the metal fit of the rim of the disk *a* with the entire surface of the lands and grooves and the outer surface of the key *a′* with the surface of the lands only.

"The friction of the key *a′* on the projectile, assisted by that of the disk pressing upon its base, will prevent any axial motion of the disk, not only guaranteeing the rotation of the projectile, but also with absolute certainty the retention in its place of the disk through its trajectory."

The general features and dimensions are shown in the plate.

Board on Experimental Guns, etc., convened under orders of the War Department, dated October, 10, 1874

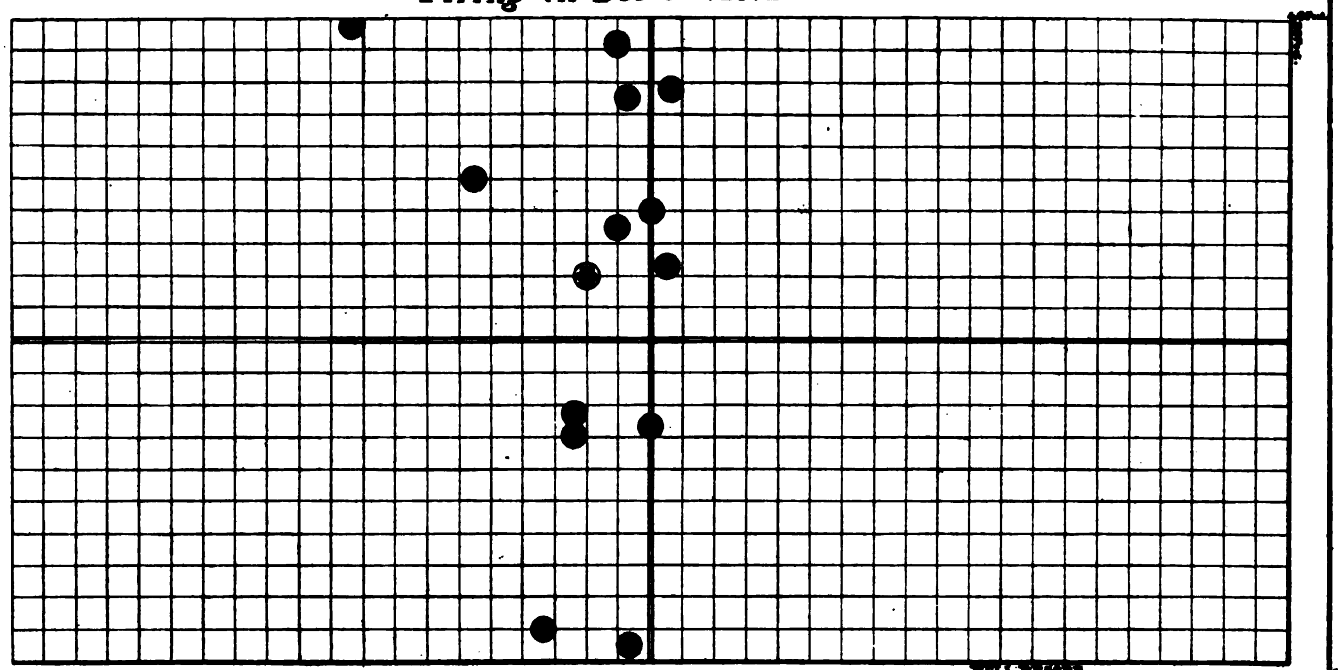
Geo. W. McKee

Captain of Ordnance, Recorder.

AM. PHOTO-LITHOGRAPHIC Co. N.Y. (OSBORNE'S PROCESS)

Plate VIII.

Firing on Dec 22d. 1874.



No. of hits, direct 13

No. of hits, ricochet 0

No. of misses 0

● Center of Impact

	FULL RECORD
Mean Horizontal Deviation from Center of Impact	1.80 Yd.
Mean Vertical " " " " " "	0.66 "
Mean Deviation " " " "	1.91 "

Board on Exp'l Guns, etc.
Convened under Orders of the
War Dept. dated Oct 10th 1874.
Geo. W. McKee
Capt of Ordnance. Recorder

AM. PHOTO-LITHOGRAPHIC Co. N.Y. (OSBORNE'S PROCESS)

Description of the manufacture of coiled wrought-iron tubes, for the conversion of cast-iron smooth-bore guns into rifles. (*Compiled from English sources.*)

The coils for the tubes are made entirely of wrought-iron bars, specially prepared by being put three times through roughing-rolls; puddled iron is hard and brittle and not by itself suitable for guns.

A sufficient number of bars are piled or faggoted together to form a bar of the size it is intended to roll. The pile, composed partly of puddled iron and partly of scrap, the former being placed always on the outside, on account of the more even surfaces, is raised to a white heat and rolled into a long bar about 24 feet long, and varying in section from 2½ to 7 inches, according to the purpose for which it is intended. It is then cut into lengths, again faggoted, raised to a welding heat, and passed between the rollers; one rolling may be sufficient. The section of the bar is slightly trapezoidal, in order that when the hot bar is wound round the mandrel, narrow side inward, the spreading of the inside and the narrowing of the outside may be neutralized, and no space left between the folds of the coils. To weld the bars together, the ends must be scarfed down and placed from opposite sides in a furnace, from which, when they arrive at a white heat, they are withdrawn and welded under an adjacent steam-hammer, sand having been thrown on the hot bars (as is indeed customary in the case of all forgings) in order to clean the surface and prevent scale forming, by converting the superficial oxide into a liquid silicate which will flow off of its own accord or be squeezed out by the hammer. Another bar is welded on in a similar manner, and so on until a sufficient length is obtained for the required coil.

The bar to be coiled having the ends flattened down, is placed on trestle rollers in front of a long reverberatory furnace with a chimney at the far end and grates along its sides. A chain being hooked into an eye or hole in the end, the bar is drawn by machinery into the furnace. When the bar arrives at a bright-red heat, the end near the door is drawn out by means of the same eye, and is attached to a pin, this end being cooled with water to prevent it tearing away with the weight of the bar; this pin is connected with a slightly tapering iron roller or mandrel fixed across and in front of the door of the furnace; the mandrel tapers in order to facilitate the removal of the finished coil. The apparatus is then put into gear, and the mandrel revolves, winding the bar around it. During the process, scales form between the folds, but their effect is almost nullified by subsequent heating and forging, sand being used to assist in liquifying the oxide as stated above. When the coil is formed, the fixed extremity is hammered off the pin and water is poured on that end to cool it, in order that the folds there may not be opened out in taking off the coil. If the coil be large, a short iron bar is placed with one end resting on the ground and the other end against the extremity which has been removed from the pin. The mandrel is then turned in the same direction as that in which it revolved when the coil was being formed, and the coil being prevented from revolving by the iron prop, is loosened and slips down toward the narrow end of the mandrel. The mandrel is then lifted up by a crane and the coil drops off.

For the welding, which, especially in tubes for lining guns, must be done with great care, the coil is placed upright in a reverberatory furnace, for were it placed on its side it should be turned over in order to be equally heated all through, and moreover drippings from the fire-brick which line the furnace would probably drop from the roof in between the folds. The tube being intended for an inner one, two furnaces have to be used; one is at a low temperature, (termed a blue light,) and when the coil arrives at a red heat it is brought out and transferred to the other, where it is brought to a welding heat. This is found to be more economical than by placing the cold coil at once into a very hot furnace, and also prevents any injury to the iron which would result from so doing.

In all cases of welding it is necessary not only to strike while the iron is hot, but that the surfaces to be joined should be perfectly clean; the white hot coil is therefore transferred from the furnace to the steam-hammer as quickly as possible, not neglecting to throw sand upon it. The coil is first placed vertically under the hammer, and receives a few smart blows to weld the folds; it is then thrown on its side, and being gradually turned, is hammered (or patted) all round to straighten it. It is then raised vertically again and a punch or mandrel rather over half the length and a little larger than the interior diameter of the coil, is hammered down its own length; the coil is next placed on its side and hammered round, that half of its length thus being made very compact and large enough to let the mandrel fall out; after this the coil is again raised vertically, and the mandrel is forced in the opposite end, and the process repeated.

The mandrels are of coiled iron and are very hard. The reason a long mandrel is not forced through the whole length of the coil is that it would tend to separate the folds.

The coil is replaced in the furnace for a second heating, and much the same process is followed to render the ring more consolidated as well as more shapely; a fine mandrel is also used to make the interior more perfect; and in order to prevent the tube from being bell-mouthed, a flexible steel bar is used under the hammer to flatten the ends.

Before the coil is removed from the hammer, water is thrown over it, which forming into steam, blows off the black scales and shreds where the work is good, but a black spot is left by the water if there is a bad part.

In order to form lining-tubes, several of these coils have to be united. To weld them together, the coils have to be faced (turned smooth at the ends) and reciprocally recessed; that is, a projection (spigot) is formed at one end of a coil, while a recess (faucet) is bored in the corresponding end of another coil. The height of the shoulder is a little greater than the depth of the recess, in order that a close joint may be obtained on the interior. The recess is then expanded by heat and shrunk over the projection, so that the two coils are attached securely enough together to admit of their being put into the furnace for welding.

For the inner barrel, which is intended to be the entire length of the bore, the tube is put crossways through a furnace so constructed that intense heat acts on the joint while the remote ends project outside.

When the joint arrives at a welding heat, a stout iron bar is passed right through the tube; this bar is keyed at one end, and by means of a screw-nut, worked by a long lever at the other end, the two coils are pressed and thus welded together. This pressure slightly bulges the metal at the junction, so it must be straightened under a steam-hammer. Another coil is then added on in a similar manner, and so on until the tube is of the required length.

The tube, if intended for an 8-inch, after having its necessary length, is then rough and fine bored to about 7.92 inches diameter, and the recess in the breech cut and tapped for the wrought-iron cup. The cup for closing the breech-end of the barrel is forged and stamped into shape under the steam-hammer. It is turned inside and outside, and furnished on the outside with a thread of four or five to the inch. It is thus screwed tightly home.

The tube in this state is proved with water-pressure of 120 pounds to the square inch, to ascertain that the cup fits tightly and that there is no leakage. The breech-end of the A tube is then turned over a length of 40 inches for the B tube previously bored, and a spiral gas-channel, 0.05 inch deep and 0.1 inch wide, is cut round its exterior, communicating with the star grooves cut in the end of the barrel and the gas-escape through the cast-iron breech.

The B tube consists of two coils united, and being rough-turned to a diameter of about 13.75 inches, and finished bored to 10.75 inches, it is shrunk on with 0.003 inch shrinkage in the diameter.

The B tube in order to be shrunk on the A tube has to be bored to that degree of smoothness which is necessary for close contact and mutual support, and is gauged to $\frac{1}{1000}$ of an inch every few inches of its length as well as at every shoulder it may have. To these measurements the shrinkage is added, and a plan made out according to which the exterior of the inner coil or A tube must be fine turned in order that it may exceed in diameter the bore of the outside coil by the required amount of shrinkage at the respective points. This plan, together with a series of corresponding "horseshoe" gauges, (very accurately adjusted,) is then furnished to the turner, who turns down the inside coil to the proper size. The operation of shrinkage is very simple. The outer coil is expanded by heat until it is sufficiently large; (if a large mass by means of a wood-fire, for which the tube itself forms the flue; if a small mass, in a reverberatory furnace at a low temperature.) It is then raised up by a traveling crane overhead, and dropped over the part on to which it is to be shrunk, which is placed vertically in a pit ready to receive it, and where the tube and jacket cool off.

The heat required in shrinking is not very great. Wrought-iron, on being heated from 62° F. (the ordinary temperature, say) to 212°, expands linearly about $\frac{1}{1000}$ part of its length, (the same amount of extension in fact as that due to its elastic limit or pressure of 12 tons to the square inch of section.) Therefore it is not necessary to have more than 500° F., which will allow a good working margin.

With respect to the mode of cooling during the process of shrinking care must be taken to prevent a long coil or tube cooling simultaneously at both ends, for this would cause the middle portion to be drawn out to an undue state of longitudinal tension. Therefore, in some cases, water is projected on one end of a coil so as to cool it first.

In order to prevent the expansion of the inner tube, thus obstructing or retarding the operation of cooling, water is circulated through the interior by means of the usual supply-pipe and siphon.

In the manufacture of these tubes samples of each week's work are tested for tensile strength and elasticity, and usually with most favorable results; the stretching-weight being about 12 tons, and the breaking-weight 23 tons per square inch.

Directions for inserting coiled wrought-iron barrels into smooth-bore guns.

The cast-iron gun should be bored out to the required size and the bore afterward carefully adjusted by lapping with leaden block and sand and water. The taper, if any, from the breech toward the muzzle, should be uniform, and in no place should the eccentricity exceed .002 inch. The muzzle-end should be screwed with an allowance of .015 between the diameters of the ring and gun; the screwed part should be longer than required for the ring, so as to insure the rear end of barrel being in contact with the cast iron at the end of the bore. A "gas-indicator hole" is drilled through the breech-end, so that it will come nearly opposite the junction-line of the plug in the barrel. All sharp edges in the interior of the gun should be taken off, and the bore carefully cleaned and oiled.

The barrel is turned to the measurements taken from the gun when finally prepared to receive the barrel. These measurements should be taken at least every 6 inches from the muzzle to within 12 inches from the breech, when they should be taken at every inch. From the muzzle to a point 24 inches from the breech, the difference between the bore and the size of the barrel should not exceed .015 of an inch, and from thence to the bottom of the bore .007 of an inch.

The barrel can be turned by means of an expanding mandrel placed in the muzzle, the center being left in the plug at the bottom of the barrel. The reduced part for the muzzle-ring should be .01 of an inch less in diameter than the bore of the ring; the breech of the ring should be square to the face against which it is screwed.

The radius at the breech-end of barrel should not be in contact with the casing, but should have .05 of an inch clearance; thus if the gun has been bored out with a 1.7 radius tool, the barrel should be turned to 1.75 inch radius.

When fitting the barrel into the gun, all bearing-surfaces should be well oiled. It is most convenient to place the gun on trestles about 3 feet 6 inches high. The barrel is lifted by a crane and entered as far as the slings will permit. The slings are then placed round the end of the expanding mandrel, and at the outer end of the mandrel are bolted two strong cross-bars by which the barrel is worked round while it is being drawn in by the crane. The indicator-hole allows the air to escape.

The plug center should not be taken off until it comes in contact with the bottom of the bore, when it may be turned off and the breech-end well marked with thin red-lead paint. The barrel should then be again tried in and well worked against the casing, great care being taken that the end of the barrel abuts truly against the bottom of the bore.

A small screw is inserted at about the middle of the length of the barrel, as shown on the drawing, to prevent the possibility of the barrel turning round in the gun during firing.

When the tube is properly adjusted, the collar is securely screwed into the muzzle. The muzzle of the gun is then faced, and the bore lapped and rifled.

The old vent is closed with a wrought-iron screw-plug, a new vent (copper-bushed) being placed nearer the muzzle.

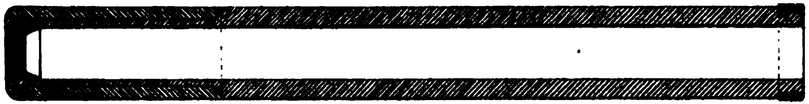
OFFICE OF BOARD ON EXPERIMENTAL GUNS,
New York City, October 2, 1875.

SIR: I have the honor herein to inclose summaries of the results of the firings of the experimental 8-inch and 9-inch rifles (wrought-iron lined) up to date, but subsequent however to the report of the board on the 8-inch rifle, given in Ordnance Notes No. 33.

It will be seen that gun No. 1 (8-inch rifle) has been fired, in all, 700

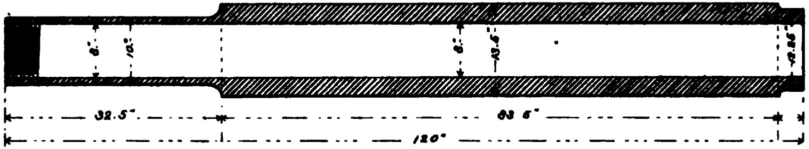
SKETCH OF A TUBE, B TUBE, CUP AND COLLAR
FOR 8-INCH RIFLE.

ESTIMATED WEIGHT 3200 lbs.

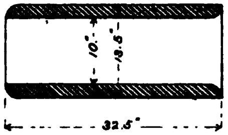


FINISHED A AND B TUBE IN SECTION.

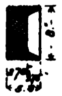
B TUBE.



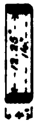
A TUBE.



CUP.



COLLAR.



Note.

The figures give the dimensions of the parts when finished.

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rounds, 187 rounds having been completed since the report of January 9, 1875. Star-gauging after the 700 rounds shows a maximum enlargement of .032 inches and at a distance of 28 inches from the bottom of the bore. An enlargement therefore of .010 inch only has resulted from the firing of the 187 additional rounds. Gutta-percha impressions show no serious increase from the effects of erosion due to the gases; the only differences being a slight increase in prominence of coil-weld marks at the seat of the charge and a normal increase of the vent. The bore, and in fact the whole system, is now practically intact, and the gun remains sound and serviceable. No special abnormal results in pressures and velocities are to be noted, as where they occur they have resulted from the use of experimental powders.

The carriage remains in good condition, and no serious imperfections have been developed by the additional firings.

The 9-inch wrought-iron lined gun has a record of 168 rounds up to date. The bore remains smooth and perfect, and no sensible erosion has occurred. The maximum enlargement, deducting the play of the tube, is about 0.01 inch. In all respects the gun is sound and in good condition; and the present firings (based upon the idea of obtaining about 6,000,000 foot-pounds energy in the projectile at the muzzle) it is intended shall cover at least 250 rounds prior to any change looking to a more severe test of the gun for endurance. It is contemplated that the records shall show at least this number on or before the 10th of October.

The carriage remains intact, but the increased violence of the recoil of this gun over the 8-inch has necessitated a slight change in the trunnion-beds of the upper carriage, to prevent the gun from rising out of them.

A hydraulic buffer and the elevating apparatus used with gun No. 1 are in use with the 9-inch rifle. The buffer gives entire satisfaction; and the elevating apparatus not only subserves its ends of elevating and depressing, but also overcomes the effects of muzzle-preponderance.

No special anomalies resulting from powder or projectiles are at present observable, except in the use of experimental powders, (see record from 156 to 161 rounds inclusive.)

The Sutcliffe 9-inch breech-loading rifle is now in position ready for firing, having had, since last report, a muzzle-collar applied. Thirteen rounds have been fired so far from this gun with satisfactory results. The programme regarding it, adopted by the board, will be carried out as early as practicable.

The Mann gun, altered for trial, is now in position and awaiting the opportunities of the board for test.

The 12-inch Thompson rifle has been delivered on the proving-ground by the founders, and awaits the completion of the platform, carriage, and chassis, &c., for its test.

The Lyman multicharge has been received, but not yet placed in position.

The above embraces all the heavy guns at present under trial.

Very respectfully, your obedient servant,

S. CRISPIN,
Bvt. Col. U. S. A., Lieut. Col. of Ordnance, President of the Board.

The CHIEF OF ORDNANCE, U. S. A.,
Washington, D. C.

[Extract.]

EXPERIMENTS AND REPORTS WITH CANNON AND PROJECTILES.—CLASSES 1, 4, AND 5.

Target record of firing with 8-inch rifle No. 1, converted from a 10-inch Rodman smooth-bore gun, by lining with wrought-iron tube, at Sandy Hook, N. J., from April 20 to September 30, 1875.

Readings of barometer, thermometer, anemometer, hygrometer, and anemoscope are omitted in this extract.

No. of fire.	Time.	Powder.		Projectile.		Elevation, in degrees.		Pressure, per square inch of bore.	Initial velocity.	Recoil.	Lot of powder.		Special remarks about each fire, such as effect on piece, sound of projectile in flight, scattering of fragments, &c.
		Kind.	Weight.	Kind.	Weight.								
	1875.		*Lbs.*		*Lbs.*			*Lbs.*	*Feet.*	*Feet.*			
514	April 20	Du Pont's hexagonal	35	Experim't'l S	167	−	1⅛	34,000	1,393	......	13	New shot fired into sand-butt	Projectile took grooves well.
515	April 20	...do	35	.. do	167	−	1⅛	28,000	1,421	......	....	......do	Do.
516	April 20	...do	35	Experim't'l G	173	−	1⅛	29,000	1,359	......	....	......do	Do.
517	April 24	...do	35	Arrick	165	−	1⅛	35,000	1,418	3.06	....	......do	Do.
518	April 24	...do	35	....do	165	−	1¼	29,500	1,432	2.75	....	......do	Do.
519	April 24	...do	35	....do	165	−	1¼	31,000	1,441	3.71	....	......do	Do.
520	April 24	...do	35	....do	165	−	1¼	28,000	1,439	3.06	....		Do.
521	April 24	...do	35	....do	165	−	1¼	33,000	1,412	2.75	....		Do.
522	April 24	...do	35	....do	180	−	1¼	28,000	1,371	3.74	....		Do.
523	April 24	...do	35	....do	180	−	1¼	28,500	1,376	3.96	....		Do.
524	April 24	...do	35	....do	180	−	1¼	28,000	1,368	3.33	....		Do.
525	April 24	...do	35	....do	180	−	1¼	33,500	1,371	3.71	....		Do.
526	April 24	...do	35	....do	180	−	1¼	30,000	Lost.	3.92	....		Do.
527	April 24	...do	35	....do	165	+	10	....	....	3.83	....	Fired over water; clear, smooth sound; gun washed out, examined, and steel-gauged.	Do.
528	April 24	...do	35	Dana	165	−	1¼	34,000	1,394	4.17	....	Fired into sand-butt	Do.
529	April 24	...do	35	....do	165	−	1¼	29,000	1,421	3.88	....	......do	Do.
530	April 24	...do	35	....do	165	−	1¼	29,500	1,427	3.33	....	......do	Do.
531	April 24	...do	35	....do	165	−	1¼	35,000	1,408	3.62	....	......do	Do.
532	April 24	...do	35	....do	165	−	1¼	41,000	1,374	3.98	....	......do	Do.
533	April 24	...do	35	....do	180	−	1¼	37,000	1,357	3.75	....	......do	Do.
534	April 24	...do	35	....do	180	−	1¼	31,500	1,357	4.12	....	......do	Do.
535	April 24	...do	35	....do	180	−	1¼	43,000	1,360	3.75	....	......do	Do.
536	April 24	...do	35	....do	180	−	1¼	36,000	1,357	3.96	....	......do	Do.
537	April 24	...do	35	....do	180	−	1¼	35,500	1,360	3.31	....	......do	Do.
538	April 24	...do	35	....do	180	+	10	....	....	3.46	....	Fired over water; clear, smooth sound; gun washed out, examined, and steel-gauged.	Do.
539	April 26	Oriental hexagonal	35	Butler	185	−	1¼	32,000	1,307	4.20	....	Fired into butt	Do.
540	April 26	...do	35	....do	186	−	1⅛	36,000	1,305	3.73	....	......do	Do.

541	April 26	...do	35	...do	186	—	1¼	42,000	1,305	3.54	....	......do	Do.
542	April 26	...do	35	..do	186	—	1¼	33,000	1,306	3.25	....	......do	Do.
543	April 26	...do	35	..do	186	—	1¼	30,500	1,308	3.60	....	......do	Do.
544	April 26	...do	35	...do	186	—	1¼	29,000	1,262	3.50	....	......do	Do.
545	April 26	....do	35	..do	169	—	1¼	29,000	1,309	3.58	....	......do	Do.
546	April 26	...do	35	....do	169	—	1¼	31,500	1,340	3.52	....	......do	Do.
547	April 26	....do	35	....do	169	—	1¼	29,500	1,376	3.65	....	......do	Do.
548	May 26	..do	35	...do	169	—	1¼	31,000	1,376	3.27	13	....	Projectile took grooves well.
549	May 26	Du Pont's hexagonal.	35	..do	169	—	1¼	32,000	1,421	3.60	14	Used small and large plug; length of indentation in small plug, 0.375.	Do.
550	May 26	....do	35	...do	170	—	1¼	28,000	1,408	3.42	..	Used small and large plug; length of indentation in small plug, 0.350.	Do.
551	Aug. 6	....do	35	Arrick	180		1	33,000	1,367	4.79	9	Fired into sand-butt	Most of the Arrick projectiles strip in butt. Projectile took grooves well.
552	Aug. 6	...do	35	....do	180	—	1	28,000	1,359	4.50	....	......do	Projectile took grooves well.
553	Aug. 6	...do	35	....do	180	—	1	31,500	1,350	4.14	....	......do	Do.
554	Aug. 6	...do	35	...do	180	—	1	30,500	1,339	3.71	....	......do	Do.
555	Aug. 6	...do	35	...do	180	—	1	32,500	1,328	3.79	....	......do	Do.
556	Aug. 6	...do	35	...do	180	—	1	32,500	1,317	3.54	....	......do	Do.
557	Aug. 6	....do	35	..do	180	—	1	28,000	1,336	3.59	....	......do	Do.
558	Aug. 6	....do	35	....do	180	—	1	29,500	1,348	3.62	....	......do	Do.
559	Aug. 6	....do	35	...do	180	—	1	28,000	1,346	3.50	....	......do	Do.
560	Aug. 6	....do	35	....do	180	—	1	26,000	1,359	3.62	....	......do	After the 569th round the gun was washed out, examined, and star-gauged by Henry A. Sinclair. Projectile took grooves well.
561	Aug. 7	....do	35	Dana	180	—	1	25,000	1,344	3.79	....	All of the Dana projectiles strip in the butt; also the sabot, being put on loose in most every case, it has to be set up with the hammer, which sometimes upsets it so that it is difficult to load the gun, the sabot catching. At the 570th round, the sabot caught so firmly that it took five or six men to ram it home.	Projectile took grooves well.
562	Aug. 7	....do	35	....do	180	—	1	28,000	1,329	3.83	....		
563	Aug. 7	....do	35	....do	180	—	1	30,000	1,316	3.67	....		
564	Aug. 7	....do	35	....do	180	—	1	33,000	1,309	3.58	....	Fired into sand-butt	Do.
565	Aug. 7	....do	35	....do	180	—	1	26,000	1,304	3.58	....	......do	Do.
566	Aug. 7	....do	35	....do	180	—	1	29,500	1,307	3.42	....	......do	Do.
567	Aug. 7	....do	35	....do	180	—	1	30,000	1,323	3.69	....	......do	Do.
568	Aug. 7	....do	35	....do	180	—	1	29,500	1,328	3.33	....	......do	Do.
569	Aug. 7	....do	35	....do	180	—	1	30,500	1,339	3.56	....	......do	Do.
570	Aug. 7	....do	35	....do	180	—	1	35,000	1,336	3.46	....	......do	After the 570th round the gun was washed out, examined, and star-gauged by H. A. Sinclair. Projectile took grooves well.
571	Aug. 9	....do	35	Butler	180	—	1	34,500	1,344	3.42	....	......do	Projectile took grooves well.
572	Aug. 9	....do	35	....do	180	—	1	27,500	1,348	3.17	....	......do	Do.
573	Aug. 9	....do	35	....do	180	—	1	30,000	1,347	3.37	....	......do	Do.
574	Aug. 9	....do	35	....do	180	—	1	30,000	1,339	3.58	....	......do	Do.
575	Aug. 9	....do	35	....do	180	—	1	26,500	1,312	3.50	....	......do	Do.

Target record of firing with 8-inch rifle No. 1, *converted from a* 10-*inch Rodman smooth-bore gun, &c.*—Continued.

No. of fire.	Time.	Powder.		Projectile.		Elevation, in degrees.	Pressure per square inch of bore.	Initial velocity.	Recoil.	Lot of powder.		Special remarks about each fire, such as effect on piece, sound of projectile in flight, scattering of fragments, &c.
		Kind.	Weight.	Kind.	Weight.							
			Lbs.		*Lbs.*		*Lbs.*	*Feet.*	*Feet.*			
576	Aug. 9	Du Pont's hexagonal.	35	Butler	180	— 1	29, 000	1, 360	3. 50	....	Fired into sand-butt	Projectile took grooves well.
577	Aug. 9	....do	35	....do	180	— 1	29, 500	1, 344	3. 42	....	......do	Do.
578	Aug. 9	....do	35	....do	180	— 1	29, 500	1, 356	3. 17	....	......do	Do.
579	Aug. 9	....do	35	....do	180	— 1	34, 000	1, 361	3. 50	....	......do	Do.
580	Aug. 9	....do	35	....do	180	— 1	36, 500	1, 374	3. 75	....	......do	After the 580th round the gun was washed out, examined, and star-gauged by H. A. Sinclair. Projectile took grooves well.
581	Aug. 10	....do	35	Arrick......	180	— 1	26, 500	Lost ..	4. 00	8	......do	Projectile took grooves well.
582	Aug. 10	....do	35	....do	180	— 1	26, 500	1, 353	3. 50	8	......do	Do.
583	Aug. 10	....do	35	....do	180	— 1	26, 000	1, 323	3. 75	....	......do	Do.
584	Aug. 10	....do	35	....do	180	— 1	33, 500	....	3. 66	....	......do	Do.
585	Aug. 10	....do	35	....do	180	— 1	29, 500	1, 346	3. 71	....	......do	Do.
586	Aug. 10	....do	35	....do	180	— 1	34, 500	1, 319	3. 42	....	......do	Do.
587	Aug. 10	....do	35	....do	180	— 1	25, 500	1, 337	3. 37	....	......do	Do.
588	Aug. 10	....do	35	....do	180	— 1	25, 000	1, 326	3. 29	....	......do	Do.
589	Aug. 10	... do	35	....do	180	— 1	29, 000	1, 334	3. 52	....	......do	Do.
590	Aug. 10	....do	35	....do	180	— 1	32, 500	1, 328	3. 46	....	......do	After the 590th round the gun was washed out, examined, and star-gauged. Projectile took grooves well.
591	Aug. 11	....do	35	Dana	180	— 1	32, 500	1, 333	3. 92	....	......do	Projectile took grooves well.
592	Aug. 11	... do	35	....do	180	— 1	33, 000	1, 303	3. 87	....	......do	Do.
593	Aug. 11	.. do	35	....do	180	— 1	29, 500	1, 322	3. 71	..	......do	Do.
594	Aug. 11	....do	35	....do	180	— 1	28, 500	1, 326	3. 79	....	......do	Do.
595	Aug. 11	....do	35	....do	180	— 1	27, 000	1, 303	3. 69	....	......do	Do.
596	Aug. 11	....do	35	....do	180	— 1	27, 500	1, 317	3. 46	....	......do	Do.
597	Aug. 11	....do	35	....do	180	— 1	26, 000	1, 279	3. 65	...	......do	Do.
598	Aug. 11	....do	35	....do	180	— 1	33, 500	1, 308	3. 46	....	......do	Do.
599	Aug. 11	....do	35	....do	180	— 1	26, 500	1, 300	3. 54	...	......do	Do.
600	Aug. 11	....do	35	....do	180	— 1	28, 500	1, 321	3. 37	....	......do	After the 600th round the gun was washed out, examined, and star-gauged by Henry A. Sinclair. Projectile took grooves well.
601	Aug. 12	....do	35	Butler	180	— 1	26, 500	1, 335	4. 00	....	......do	Projectile took grooves well.
602	Aug. 12	....do	35	....do	180	— 1	26, 000	1, 322	3. 79	....	......do	Do.
603	Aug. 12	....do	35	....do	180	— 1	29, 000	1, 341	3. 60	....	......do	Do.
604	Aug. 12	....do	35	....do	180	— 1	26, 000	1, 341	3. 75	....	......do	Do.

605	Aug. 12	....do	35	....do	180	- 1	29,000	1,344	3.71	....	......do	Do.
606	Aug. 12	....do	35	....do	180	— 1	31,500	1,342	3.95	...	......do	Do.
607	Aug. 12	....do	35	....do	180	— 1	33,000	1,334	3.71	....	......do	Do.
608	Aug. 12	....do	35	....do	180	— 1	28,000	1,335	3.71	....	......do	Do.
609	Aug. 12	....do	35	....do	180	— 1	27,500	1,345	3.79	....	......do	Do.
610	Aug. 12	....do	35	....do	180	- 1	32,500	1,339	3.50	....	......do	After the 610th round the gun was washed out, examined, and star-gauged by Henry A. Sinclair. Projectile took grooves well.
611	Aug. 12	....do	35	Arrick......	180	+ 2 55	....	....	3.50	7	Fired at target........................	Projectile took grooves well.
612	Aug. 12	....do	35	....do	180	+ 3	....	....	3.46	....	......do	Sabot stripped. Projectile took grooves well.
613	Aug. 12	....do	35	Dana	180	+ 3 10	....	....	3.42	....	......do	Projectile took grooves well.
614	Aug. 12	....do	35	Arrick......	180	+ 3 5	....	....	3.42	...	......do	Do.
615	Aug. 12	....do	35	Dana	180	+ 3 10	....	....	......	...	......do	Do.
616	Aug. 12	....do	35	Butler	180	+ 2 55	....	....	3.46	7	......do	Do.
617	Aug. 12	....do	35	Arrick......	180	+ 3 5	....	....	......	...	......do	
618	Aug. 12	....do	35	Dana	180	+ 3 10	....	....	3.46	...	......do	Sabot stripped.
619	Aug. 12	....do	35	Butler	160	+ 3	....	....	3.37	...	......do	
620	Aug. 12	....do	35	Arrick......	180	+ 3 5	....	....	3.17	...	......do	Sabot stripped.
621	Aug. 12	....do	35	Dana	180	+ 3 10	....	....	3.08	...	......do	
622	Aug. 12	....do	35	Butler	180	+ 3	....	....	3.05	...	......do	
623	Aug. 13	....do	35	Arrick......	180	+ 5	....	....	3.88	...	Fired over water; range 2,607 yards.	
624	Aug. 13	....do	35	....do	180	+ 5	....	....	3.62	...	Fired over water; range 2,599 yards.	
625	Aug. 13	....do	35	....do	180	+ 5	....	....	3.21	...	Fired over water; range 2,609 yards.	2,635.8 yards.
626	Aug. 13	....do	35	....do	180	+ 5	....	....	3.54	...	Fired over water; range 2,682 yards.	
627	Aug. 13	....do	35	....do	180	+ 5	....	....	3.39	...	Fired over water; range 2,682 yards.	
628	Aug. 13	....do	35	Dana	180	+ 5	....	....	3.88	...	Fired over water; range 2,590 yards	
629	Aug. 13	....do	35	....do	180	+ 5	....	....	2.92	...	Fired over water; range 2,617 yards.	
630	Aug. 13	....do	35	....do	180	+ 5	....	....	3.12	...	Fired over water; range 2,611 yards.	2,604.8 yards.
631	Aug. 13	....do	35	....do	180	+ 5	....	....	3.00	...	Fired over water; range 2,568 yards.	
632	Aug. 13	....do	35	....do	180	+ 5	....	....	2.75	...	Fired over water; range 2,638 yards	
633	Aug. 13	....do	35	Butler	180	+ 5	....	....	3.48	...	Fired over water; range 2,572 yards.	
634	Aug. 13	....do	35	....do	180	+ 5	....	....	3.00	...	Fired over water; range 2,590 yards.	
635	Aug. 13	....do	35	....do	180	+ 5	....	....	3.17	...	Fired over water; range 2,607 yards.	2,608 yards.
636	Aug. 13	....do	35	....do	180	+ 5	....	....	3.00	...	Fired over water; range 2,638 yards	
637	Aug. 13	....do	35	....do	180	+ 5	....	....	2.66	...	Fired over water; range 2,633 yards.	
638	Aug. 13	....do	35	Arrick......	180	+10	....	....	2.83	...	Fired over water; range 4,423 yards.	
639	Aug. 13	....do	35	....do	180	+10	....	....	3.38	...	Fired over water; range 4,484 yards.	
640	Aug. 13	....do	35	....do	180	+10	....	....	2.58	...	Fired over water; range 4,427 yards.	4,472.5 yards.
641	Aug. 13	....do	35	....do	180	+10	....	....	2.79	...	Fired over water; range 4,511 yards	
642	Aug. 13	....do	35	....do	180	+10	....	....	2.79	...	Fired over water; range 4,445 yards	
643	Aug. 13	....do	35	Dana	180	+10	....	....	3.17	...	Fired over water; range 4,419 yards.	
644	Aug. 13	....do	35	....do	180	+10	....	....	3.08	...	Fired over water; range 4,419 yards.	
645	Aug. 13	....do	35	....do	180	+10	....	....	2.79	...	Fired over water; range 4,419 yards.	4,428 yards.
646	Aug. 13	....do	35	....do	180	+10	....	....	2.77	...	Fired over water; range 4,406 yards	
647	Aug. 13	....do	35	....do	180	+10	....	....	2.62	...	Fired over water; range 4,449 yards	

Target record of firing with 8-inch rifle No. 1, converted from a 10-inch Bodman smooth-bore gun, &c.—Continued.

Number of fire.	Time.	Powder.		Projectile.		Elevation, in degrees.	Pressure per square inch of bore.	Initial velocity.	Recoil.	Lot of powder.		Special remarks about each fire, such as effect on piece, sound of projectile in flight, scattering of fragments, &c.
		Kind.	Weight.	Kind.	Weight.							
	1875.		*Lbs.*		*Lbs.*		*Lbs.*	*Feet.*	*Feet.*			
648	Aug. 13	Du Pont's hexagonal.	35	Butler	180	+10	......	......	2.50	....	Fired over water; range 4,301 yards.	
649	Aug. 13	....do	35	....do	180	+10	......	......	3.08	....	Fired over water; range 4,375 yards.	
650	Aug. 13	....do	35	....do	180	+10	......	......	2.46	7	Fired over water; range, 4,414 yards.	4,390 yards.
651	Aug. 13	....do	35	....do	180	+10	......	......	2.88	7	Fired over water; range, 4,476 yards.	
652	Aug. 13	....do	35	....do	180	+10	......	......	2.91	7	Fired over water; range, 4,354 yards.	
653	Aug. 14	....do	35	Dana	180	+ 3 10	......	......	3.92	10	Fired at target	After the 652d round the gun was washed out, examined, and star-gauged by H. A. Sinclair Projectile took grooves well. Projectile took grooves well.
654	Aug. 14	....do	35	Arrick	180	+ 3 5	......	......	3.54	....	......do	Do.
655	Aug. 14	....do	35	Butler	180	+ 3 5	......	......	3.62	....	......do	Do.
656	Aug. 14	....do	35	Dana	190	+ 3 10	......	......	3.50	....	......do	Do.
657	Aug. 14	....do	35	Arrick	180	+ 3 8	......	......	3.29	....	......do	Do.
658	Aug. 14	....do	35	Butler	180	+ 3 10	......	......	3.42	....	......do	Do.
659	Sept. 28	....do	35	....do	180	— 1	24,000	1,344	3.79	8	Fired into sand-butt	Do.
660	Sept. 28	....do	35	....do	180	+10	27,000	......	3.09	....	Fired to sea; clear, smooth sound	Do.
661	Sept. 28	....do	35	....do	184	+12½	27,500	......	2.92	....	......do	Do.
662	Sept. 28	....do	35	....do	180	— 1	27,500	1,348	3.21	....	Fired into sand-butt	Do.
663	Sept. 28	....do	35	....do	180	+ 3	26,500	......	2.96	....	Fired at target; clear, smooth sound ...	Do.
664	Sept. 28	....do	35	....do	184	— 1	29,000	1,359	3.05	....	Fired into sand-butt	Do.
665	Sept. 28	....do	35	....do	183	— 1	26,500	1,331	3.05	....	......do	Do.
666	Sept. 30	....do	35	....do	184	— 1	24,500	1,320	2.73	....	......do	Do.
667	Sept. 30	....do	35	....do	185	— 1	......	......	3.02	....	......do	Do.
668	Sept. 30	....do	35	....do	185	— 1	......	......	2.62	....	......do	Do.
669	Sept. 30	....do	35	....do	187	— 1	......	......	2.54	....	......do	Do.
670	Sept. 30	....do	35	....do	186	— 1	29,000	1,351	2.62	12	......do	Do.
671	Sept. 30	....do	35	....do	185	— 1	......	......	2.58	....	......do	Do.
672	Sept. 30	....do	35	....do	187	— 1	......	......	2.67	....	......do	Do.
673	Sept. 30	....do	35	....do	189	— 1	......	......	2.60	....	......do	Do.
674	Sept. 30	....do	35	....do	184	— 1	......	......	2.50	....	......do	Do.
675	Sept. 30	....do	35	....do	186	— 1	30,500	1,368	2.71	....	......do	Do.
676	Sept. 30	....do	35	....do	185	— 1	......	......	2.39	....	......do	Do.
677	Sept. 30	....do	35	....do	185	— 1	......	......	2.75	....	......do	Do.
678	Sept. 30	....do	35	....do	185	— 1	......	......	2.50	10	......do	Do.
679	Sept. 30	....do	35	....do	185	— 1	......	......	2.62	....	......do	Do.
680	Sept. 30	....do	35	....do	185	— 1	24,000	1,299	2.39	....	......do	Do.
681	Sept. 30	....do	35	....do	185	— 1	25,000	1,305	2.37	....	......do	Do.
682	Sept. 30	....do	35	....do	173	— 1	......	......	2.71	....	......do	Do.
683	Sept. 30	....do	35	....do	170	— 1	......	......	2.37	....	......do	Do.

684	Sept. 30	do	35	do	170	— 1			2.33		do	Do.
685	Sept. 30	do	35	do	171	— 1	24,500	1,337	2.87		do	Do.
686	Sept. 30	do	35	do	171	— 1			2.56		do	Do.
687	Sept. 30	do	35	do	169	— 1			2.96		Fired at target; clear, smooth sound	Do.
688	Sept. 30	do	35	do	169	— 1			2.98		Fired into sand-butt	Do.
689	Sept. 30	do	35	do	169	— 1			3.46		do	Do.
690	Sept. 30	do	35	do	169	— 1	25,000	1,368	3.21		do	Do.
691	Sept. 30	do	35	do	169	+ 5			2.96		Fired out to sea; clear, smooth sound	Do.
692	Sept. 30	do	35	do	168	+10			2.79		do	Do.
693	Sept. 30	do	35	do	169	— 1			2.35		Fired into sand-butt	Do.
694	Sept. 30	do	35	do	169	— 1			3.15		do	Do.
695	Sept. 30	do	35	do	168	— 1	24,000	1,358	3.25		do	Do.
696	Sept. 30	do	35	do	168	— 1			3.04		do	Do.
697	Sept. 30	do	35	do	168	— 1			2.73		do	Do.
698	Sept. 30	do	35	do	168	— 1			2.62		do	Do.
699	Sept. 30	do	35	do	166	— 1			3.08		do	Do.
700	Sept. 30	do	35	do	163	— 1	26,500	1,345	2.29		do	Do.

Table of enlargements of 8-*inch converted rifle No.* 1.

Inches from bottom of bore.	Original play of tube.	Original diameter of bore.	Enlargement after five charges of 20 to 35 pounds.	A.—Enlargement after 12 rounds, seven battering-charges.	Enlargements from column "A" after "setting up" of tube.					Total enlargement after 513 rounds, including the "set up" of tube.	Total enlargement after 700 rounds, including the "set up" of tube.
					After a total of 100 rounds.	After a total of 203 rounds.	After a total of 310 rounds.	After a total of 411 rounds.	After a total of 513 rounds.		
11	0.0105	7.985	No enlargement of bore. Tube not "set out."	0.022	0.005	0.005	0.005	0.005	0.005	0.027	0.025
13	0.0105	7.985		0.020	0.005	0.005	0.005	0.005	0.005	0.025	0.024
16	0.0105	7.985		0.019	0.004	0.004	0.004	0.004	0.005	0.024	0.022
19	0.0105	7.985		0.019	0.006	0.006	0.006	0.007	0.008	0.027	0.022
22	0.0105	7.985		0.022	0.006	0.006	0.007	0.011	0.018	0.040	0.038
25	0.0105	7.985		0.020	0.007	0.008	0.009	0.012	0.016	0.036	0.037
28	0.0105	7.985		0.017	0.008	0.009	0.010	0.013	0.015	0.032	0.043
31	0.0105	7.985		0.013	0.009	0.010	0.011	0.013	0.015	0.028	0.030
34	0.0100	7.985		0.009	0.006	0.007	0.008	0.010	0.011	0.020	0.018
37	0.0100	7.985		0.007	0.004	0.004	0.005	0.007	0.008	0.015	0.012
40	0.0100	7.985		0.003	0.003	0.003	0.005	0.006	0.007	0.010	0.007
45	0.0100	7.985		0.002	0.002	0.002	0.003	0.004	0.005	0.007	0.006
50	0.0095	7.985		0.002	0.002	0.002	0.002	0.003	0.004	0.006	0.004
55	0.0095	7.985		0.001	0.001	0.001	0.001	0.002	0.003	0.004	0.004
60	0.0095	7.985		0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.0035
65	0.0095	7.985		0.001	0.000	0.000	0.000	0.001	0.002	0.003	0.0025
70	0.0095	7.985		0.000	0.000	0.000	0.000	0.000	0.002	0.002	0.0015
80	0.0095	7.985		0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001
90	0.0095	7.985		0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.060
100	0.0095	7.985		0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.000
118	0.0095	7.985		0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.000

Board on experimental guns, &c., convened under orders of the War Department dated October 10, 1874.

GEO. W. McKEE,
Captain of Ordnance, Recorder.

[Extract.

TABLE No. 1.—*Record of firings for endurance with a 9-inch experimental rifle, from August 16 to September 22, inclusive, 1875, at Sandy Hook, N. J.*

Description of gun.	Date.	Number of shots.	Charge.				Projectile.				Mean observed velocities of the projectile at 110 feet from the muzzle of the gun, as recorded by Le Boulengé's chronograph.	Velocities at the muzzle.	Energy of projectile.		Gas-pressure per square inch of surface of bore, as taken with Rodman's internal pressure gauge.	Recoil of upper carriage.
			Kind of powder.	Cartridge.			Kind.	Weight.	Length.	Diameter.			Total at the muzzle.	Per inch of the shot's circumference.		
				Weight.	Height.	Diameter.							$\frac{PV^2}{2g}$	$\frac{PV^2}{2g\,2\pi R}$		
	1875.				*In.*	*In.*			*In.*	*In.*						*Feet.*
9-inch converted gun, No. 3.	August 16	2	Du Pont's hexagonal F U, (E V & F P and oriental experimental.)	25	14	8.25	Butler	215	20¾	8.94	1089	1094	3,995,648	142,261	16,250	*3.46
	do	2		30	16¼	8.25	do	215	20¾	8.94	1179	1185	4,688,018	166,810	19,500	*3.75
	do	2		35	18¾	8.25	do	215	20¼	8.94	1223	1230	5,050,830	176,234	21,500	*4.02
	August 17	1		35	18¾	8.25	do	247	20¼	8.94	1226	1232	5,821,468	207,266	23,500	5.17
	August 16 and 17	4		40	20¼	8.25	do	215	20¼	8.94	1300	1308	5,711,735	203,346	24,125	4.50
	August 17 and September 21	7		40	20¼	8.25	do	230	20¾	8.94	1387	1395	†6,950,689	247,449	†34,000	5.58
	September 18, (average)	15		40	20¾	8.25	do	234	19¼	8.94	1296	1303	6,169,057	219,642	26,833	4.77
	August 17, 26, and 27 and September 7.	18		45	23	8.25	do	215	20¼	8.94	1370	1378	6,339,442	225,708	26,611	5.31
	September 6 and 7, (average)	19		45	23	8.25	do	204	19¼	8.94	1392	1401	6,217,568	221,369	26,326	4.81
	September 8 and 10	33		45	23	8.25	Arrick	200	18¾	8.95	1408	1418	6,244,484	222,327	26,062	5.45
	September 10 and 21	17		40	20¼	8.25	do	225	19¼	8.95	1343	1351	6,376,866	227,041	29,118	5.26
	September 9 and 10	40		45	23	8.25	Dana	200	19	8.94	1379	1388	5,983,056	213,019	25,225	5.47
	September 22	7		40	20¼	8.25	do	232	18¾	8.94	1246	1252	5,646,909	201,051	25,556	4.71
	August 17	1		40	20¾	8.25	Butler	247	20¾	8.94	1247	1253	6,021,618	214,392	25,500	......
	Number of shots fired	168														

* Preliminary trial.

† Experimental powders.

Board on experimental guns, &c., convened under orders of the War Department dated October 10, 1874.

[Extract.]

EXPERIMENTS AND REPORTS WITH CANNON AND PROJECTILES—CLASSES 1, 4, AND 5.

Target-record of firing with 9-inch rifle No. 3, converted from a 10-inch Rodman smooth-bore gun, by lining with wrought-iron tube, at Sandy Hook, N. J., from October 5 to October 8, 1875.

No of fire.	Time.	Powder.		Projectile.		Elevation in degrees.	Pressure per square inch of bore.	Initial velocity.	Recoil.	Number of lot of powder.		Special remarks about each fire, such as effect on piece, sound of projectile in flight, scattering of fragments, &c.
		Kind.	Weight.	Kind.	Weight.							
			Lbs.		*Lbs.*		*Lbs.*	*Feet.*	*Feet.*			
169	*A. M.* Oct. 5	Dupont's hexagonal	40	Dana	231	— 1	23000	1261	4.92	10	Fired into sand-butt	Projectile took grooves well.
170	Oct. 5	....do	40	....do	231	— 1	25000	1255	4.94	10	......do	Do.
171	Oct. 5	....do	40	....do	231	— 1	24000	1268	4.96	10	......do	Do.
172	Oct. 5	....do	40	....do	231	— 1	24000	1252	4.94	10	......do	Do.
173	Oct. 5	....do	40	....do	231	— 1	26000	1263	4.92	10	......do	Do.
174	Oct. 5	....do	40	....do	231	— 1	25500	1275	4.94	10	......do	Do.
175	Oct. 5	....do	40	....do	231	— 1	23500	1265	4.94	10	......do	Do.
176	Oct. 5	....do	40	....do	231	— 1	26500	1270	4.96	10	......do	Do.
177	Oct. 5	....do	40	....do	231	— 1	33000	1282	4.96	10	......do	Do.
178	Oct. 5	....do	40	....do	231	— 1	25000	1259	4.96	10	......do	Do.
179	Oct. 5	....do	40	....do	231	— 1	24500	1171	5.00	10	......do	Do.
180	Oct. 5	....do	40	....do	232	— 1	24500	1252	5.00	10	......do	Do.
181	Oct. 5	....do	40	....do	232	— 1	23500	1182	5.00	1	......do	Do.
182	Oct. 5	....do	40	....do	232	— 1	25000	1230	5.04	1	......do	Do.
183	Oct. 5	....do	40	....do	232	— 1	23500	1241	5.10	1	......do	Do.
184	Oct. 5	....do	40	....do	232	— 1	27000	1243	5.17	1	......do	Do.
185	Oct. 5	....do	40	....do	232	— 1	25500	1270	5.21	1	......do	Do.
186	Oct. 5	....do	40	....do	232	— 1	28000	1259	5.23	1	......do	Do.
187	Oct. 5	....do	40	....do	233	— 1	25000	1259	5.23	1	......do	Do.
188	Oct. 5	....do	40	....do	233	+ 5	26000	Not taken.	5.25	1	Fired over water	Do.
189	Oct. 5	....do	40	Arrick	225	— 1	25000	1294	5.31	1	Fired into sand-butt	Do.
190	Oct. 5	....do	40	....do	225	— 1	24000	1285	5.33	1	......do	Do.
191	Oct. 5	....do	40	....do	225	— 1	24500	1284	5.33	1	......do	Do.
192	Oct. 5	....do	40	....do	225	— 1	24500	1292	5.39	1	......do	Do.
193	Oct. 5	....do	40	....do	225	— 1	24500	1269	5.39	1	......do	Do.
194	Oct. 5	....do	40	....do	225	— 1	25000	1293	5.42	1	......do	Do.
195	Oct. 5	....do	40	....do	225	— 1	25000	1293	5.42	1	......do	Do.
196	Oct. 5	....do	40	....do	225	— 1	25500	1290	5.46	1	......do	Do.
197	Oct. 5	....do	40	....do	225	— 1	25500	1303	5.46	1	......do	Do.
198	Oct. 5	....do	40	....do	225	— 1	27500	1302	5.49	1	......do	Do.
199	Oct. 5	....do	40	....do	225	— 1	25000	1281	5.50	1	......do	Do.
200	Oct. 5	....do	40	....do	225	— 1	24000	1247	5.50	1	......do	Do.
201	*P. M.* Oct. 5	....do	40	....do	225	— 1	24500	1211	5.27	1	......do	Do.
202	Oct. 5	....do	40	....do	225	— 1	24000	1243	5.27	1	......do	Do.

203	Oct.	5	....do	40	....do	225	— 1	24500	1941	5. 31	1	......do	Do.
204	Oct.	5	....do	40	....do	225	— 1	24500	1971	5. 37	1	......do	Do.
205	Oct.	5	....do	40	....do	225	— 1	25000	1963	5. 37	1	......do	Do.
206	Oct.	5	....do	40	....do	225	— 1	23500	1961	5. 37	1	......do	Do.
207	Oct.	5	....do	40	....do	225	— 1	24000	1969	5. 42	1	......do	Do.
208	Oct.	5	....do	40	....do	225	— 1	21000	1261	5. 46	1	......do	Do.
209	Oct.	5	....do	40	Butler	234	— 1	24000	1225	5. 50	1	......do	Do.
210	Oct.	5	....do	40	....do	232	— 1	23500	1250	5. 50	1	......do	Do.
211	Oct.	5	....do	40	....do	232	— 1	25000	1248	5. 54	1	......do	Do.
212	Oct.	5	....do	40	....do	233	+10	26000	....	5. 60	5	Fired over water	Do.
213	Oct.	5	....do	40	....do	230	+10	25000	....	5. 58	5	......do	Do.
214	Oct.	7	....do	40	....do	233	— 1	26000	1294	5. 71	5	Fired into sand-butt	Do.
215	Oct.	7	....do	45	....do	201	— 1	27500	1417	5. 71	5	......do	Do.
216	Oct.	7	....do	45	....do	201	— 1	23500	1371	5. 65	5	......do	Do.
217	Oct.	7	....do	45	....do	201	— 1	29000	1397	5. 69	5	......do	Do.
218	Oct.	7	....do	45	....do	202	— 1	26000	1402	5. 75	5	......do	Do.
219	Oct.	7	....do	45	....do	202	— 1	27000	1433	5. 73	5	......do	Do.
220	Oct.	7	....do	45	....do	201	— 1	28000	1436	5. 75	5	......do	Do.
221	Oct.	7	....do	45	....do	201	— 1 3/16	27500	1437	5. 81	5	......do	Do.
222	Oct.	7	....do	45	Arrick	200	— 1 3/16	27500	1444	5. 46	5	Fired into sand-butt. Cylinder filled with one gallon of water.	Do.
223	Oct.	7	....do	45	....do	200	— 1¼	27500	1443	5. 50	5	Fired into sand-butt	Do.
224	Oct.	7	....do	45	....do	200	— 1¼	27500	1447	5. 50	5	......do	Do.
225	Oct.	7	....do	45	....do	200	— 1¼	26000	1431	5. 62	5	......do	Do.
226	Oct.	7	....do	45	....do	200	— 1¼	28000	1421	5. 65	5	......do	Do.
227	Oct.	7	....do	45	....do	200	— 1¼	27000	1426	5. 94	5	......do	Do.
228	Oct.	7	....do	45	....do	200	— 1¼	25000	1433	5. 54	5	......do	Do.
229	Oct.	7	....do	45	....do	200	— 1¼	27500	1443	5. 60	5	......do	Do.
230	Oct.	7	....do	45	....do	200	— 1 3/16	27500	....	5. 62	5	......do	Do.
231	Oct.	7	....do	45	....do	200	— 1¼	27500	1442	5. 69	5	......do	Do.
232	Oct.	7	....do	45	Dana	200	— 1 3/16	27500	1422	5. 69	5	......do	Do.
233	Oct.	7	....do	45	....do	200	— 1¼	28000	1419	5. 75	5	......do	Do.
234	Oct.	7	....do	45	....do	200	— 1¼	30500	1369	5. 75	5	......do	Do.
235	Oct.	7	....do	40	Arrick	225	— 1 3/16	25500	1311	5. 44	5	Fired into sand-butt. Cylinder filled with one gallon of water.	Do.
236	Oct.	8	....do	40	Arrick	225	— 1¼	27000	1287	5. 77	5	Fired into sand-butt	Do.
237	Oct.	8	....do	40	....do	225	— 1¼	24500	1313	5. 39	5	......do	Do.
238	Oct.	8	....do	40	Dana	232	— 1¼	26500	1266	5. 46	5	Fired into sand-butt. Piston of pressure-plug broke.	Do.
239	Oct.	8	....do	40	....do	230	— 1¼	26500	1306	5. 52	5	Fired into sand-butt	Do.
240	Oct.	8	....do	40	....do	231	— 1 3/16	30500	1281	5. 58	5	......do	Do.
241	Oct.	8	....do	40	....do	231	— 1¼	30500	1288	5. 67	5	Fired into sand-butt. A little gas got in the plug.	Do.
242	Oct.	8	....do	40	....do	231	— 1¼	26000	1284	5. 77	5	Fired into sand-butt	Do.
243	Oct.	8	....do	40	....do	231	— 1 3/16	23500	1256	5. 46	5	......do	Do.
244	Oct.	8	....do	40	....do	231	— 1 3/16	25000	1285	5. 52	5	......do	Do.
245	Oct.	8	....do	40	....do	232	— 1 3/16	25000	1272	5. 56	5	......do	Do.
246	Oct.	8	....do	40	Butler	230	— 1¼	24000	1292	5. 62	5	......do	Do.
247	Oct.	8	....do	40	....do	230	— 1 3/16	25500	1293	5. 71	5	......do	Do.
248	Oct.	8	....do	40	....do	230	1 3/16	26500	1301	5. 75	5	Fired into sand-butt. Considerable gas got in the plug.	Do.

Target-record of firing with 9-inch rifle No. 3, &c.—Continued.

No. of fire.	Time.	Powder.		Projectile.		Elevations in degrees.	Pressure per square inch of bore.	Initial velocity.	Recoil.	Number of lot of powder.		Special remarks about each fire, such as effect on piece, sound of projectile in flight, scattering of fragments, &c.
		Kind.	Weight.	Kind.	Weight.							
	P. M.		*Lbs.*		*Lbs.*		*Lbs.*	*Feet.*	*Feet.*			
249	Oct. 8	Dupont's hexagonal.	40	Dana	230	— 1¼	26500	1290	5.37	6	Fired into sand-butt. Cylinder filled with one gallon of water.	Projectile took grooves well.
250	Oct. 8	....do	40	....do	230	— 1¾	26500	1293	5.46	6	Fired into sand-butt. At the 250 round only 6 gallons remained in cylinder.	Do.

October 5, A. M.—At beginning of firing, barometer 30 037; thermometer 61; relative humidity, 91 per cent. At the 184th round, barometer 30.037; thermometer 67; relative humidity, 83 per cent. At beginning, velocity of wind 6 miles per hour. At 190th round, velocity of wind 2.10 miles per hour.

October 5, P. M.—Barometer 30.080; thermometer 68; relative humidity, 77 per cent.; velocity of wind 10.50 miles per hour.

October 7.—Barometer 29.905; thermometer 64; relative humidity, 92 per cent.; velocity of wind, morning, 10.07 miles per hour—afternoon, 20 miles per hour.

October 8.—Barometer 30.054; thermometer, 51.5. After the 250th round the gun was washed out, examined, and star-gauged; no change.

APPENDIX F.

WASHINGTON, *November* 1, 1875.

SIR: I have the honor to submit herewith a report on the tests of steel made by me in connection with the selection of suitable material for the fabrication of guns on my system of construction. The number of varieties examined is considerable, and the experiments, it is hoped, will be found to contribute information of interest and value outside of the particular department of the arts to which they owe their origin, in regard to the combination of the various properties of steel which may be found in individual specimens, the result of the use of different materials and methods of manufacture.

The value of the experiments as a contribution to the improvement of methods of manufacture would, of course, be greatly enhanced by correct and full chemical analyses of representative specimens. Analyses of a few are presented, and all the specimens are carefully marked and preserved, in hope that others may yet be subjected to chemical examination.

It is a satisfaction to state that the most excellent specimens were of American production.

I remain, very respectfully, your obedient servant,

W. E. WOODBRIDGE.

General S. V. BENÉT,
Chief of Ordnance.

REPORT.

The primary object of these experiments was to ascertain, from the examination of such samples as might be found available, the material best suited for use, in the form of wire, in the construction of guns, and to aid manufacturers of steel in securing a more uniform excellence of quality, by affording them an opportunity of recognizing, by means of more exact tests than they have been accustomed to apply, the comparative mechanical value of their products and the conditions under which the best results had been obtained.

In considering what combination of properties is requisite to constitute high excellence in a material for the construction of guns of the largest caliber, it is necessary to give attention to the manner in which the strains to which it is subjected are applied.

First and most evident is the general high pressure within the bore, acting in a manner comparable with that of a liquid gradually injected and confined within a cylinder. To meet this, cohesive strength, without regard to susceptibility to extension or change of form, is the quality required. But as the pressure is applied with great rapidity, and as time is an element in the communication of strain, it is necessary that the material immediately surrounding the bore, unable of itself to oppose the requisite resistance, should be *extensible*, in order that it shall not be ruptured before it can receive the support of the adjoining exterior material, and *elastic*, that the extension shall not be permanent. An elastic material, acted on by unequal strains, is necessarily thrown into vibrations.

In the case of a gun, not only does the rapid application of the internal pressure produce vibration, but an additional cause is found in the inequality of the internal pressures, arising in part from the variable progress of the inflammation of the charge, and more largely from the changing relation of the pressure and inertia of the gases during their expansion and the progress of the projectile through the bore.

Vibration, which is a necessary result of a necessary quality of the material considered, requires the addition of another property to restrain its unfavorable influence on cohesive strength. A perfectly elastic body conserves the energy employed in imparting to it vibratory movement, the amplitude of the vibrations being increased by each accession of energy until the play of the particles is carried, in some part of the body, beyond the limit of extensibility, when rupture must occur. The interference and coincidence of vibratory waves of different lengths, it should be noticed, must produce local diminutions and augmentations of the space through which the particles play, and consequently local strains, which, in a *perfectly* elastic material, will result in fracture, while the general vibratory action may be slight. If, however, the material possesses the capability of having its form changed beyond the bounds of its elastic movements without rupture, or, in other words, the property imperfectly defined by malleability or ductility, many repeated applications of a force otherwise destructive may be endured without apparent injury, the excess of energy being consumed in the changes of form, which might be designated *permanent* were they not often reversed with each vibration of the ductile material. Each disappearance of energy in the manner just mentioned, that is, in change of *quiescent form*, is of course accompanied by a change of properties in the material itself; a change which diminishes and would finally destroy its ductility.

These facts manifest themselves in the now well-known deterioration of large guns from the repeated use of charges much smaller than were formerly used in proof.

As no limit is assignable to the force it is desirable to impart to a projectile, it is impossible to define any bounds to the caliber and strength to be demanded for artillery. The problem is, therefore, the production and selection of a material combining in due proportions, and in the highest attainable degree, cohesive strength, elastic extensibility, and the capability of changing form (and retaking it) under strains which exceed its elastic limit. Neither of these properties is found in its highest degree in a material possessing either of the others also in the highest degree, and as yet no fixed relation is known between them.

It may be stated, however, as a general rule, which is particularly applicable to steel, that, with the same material, the means resorted to for increasing strength increase elasticity, but diminish extensibility; and also that in the effort to increase extensibility, ultimate strength and resistance within the limits of elastic extensibility are made less. Some of the specimens included in these tests present the most favorable exceptions that have come to the knowledge of the writer, and it is much to be hoped that the qualities they represent may become less exceptional in production; for it appears to be beyond the power of the best manufacturers to repeat, or closely approximate at will, their *best* **results.**

Of all the substances available for gun construction, some of the varieties of steel, especially when wrought to small dimensions, combine the qualities stated to be desirable in the greatest degree.

The greater part of the experiments have been made upon steel in the form of wire. The size and shape previously fixed upon for use in the construction of experimental guns, three-tenths of an inch square, (or nearly of that measurement,) was most commonly employed.

Other experiments were, however, made for comparison, as will be noticed in examining the accompanying tables.

TENSILE TESTING-MACHINE.

The tensile tests were made with the testing-machine of the Ordnance Department at the Washington navy-yard, designed by the late General Rodman, and described in his Report on Metals for Cannon.

Though made a number of years ago, it is, in my estimation, in some important respects better for tests of that kind than any other differently constructed that has come to my knowledge since. It has, however, one feature which is objectionable when used for testing long specimens of considerable extensibility. The strain being applied through the medium of the lever which is also a part of the arrangement for weighing its amount, it frequently happens that the whole motion of the lever is insufficient to take up the elongation of which the specimen is capable, so that the machine has to be re-adjusted, sometimes more than once. It is also unfortunate that the principal lever of the weighing-apparatus should change its position when in equilibrium, from another point of view. Some friction of the parts is unavoidable in making this change, and the force requisite to overcome it is not applied in the axial line of the specimen, as it should be. It may be noticed that specimens taken from the machine after having been strained nearly to their breaking-point, and afterward replaced, often fail before the previous strain has been reached. This is never the effect of release alone, without change of position of machine or specimen.

The rigidity of the parts of the machine concerned in the transmission of power from the point of application to the specimen, is very favorable to observing some of the changes just preceding rupture, especially when the specimen is small; changes which cannot be observed in the use of machines in which the connection just referred to is considerably more elastic.

TENSILE SPECIMENS.

The tensile specimens, when they consisted of plain wires, were held, for testing, at both ends, by means of clamps, figured in Plate 2. Fig. 1 is a longitudinal section, in which a portion of the wire is seen *in situ*. A view of the end receiving the wires is given in Fig. 2. The other end of each clamp is fitted to be received in the place of a turned specimen in the testing-machine.

Plate 3 presents the form of the ends of other tensile specimens. The screw, Fig. 1, enters a block of metal constituting a head which the machine is adapted to receive. Figs. 2 and 3 are side and end views of a portion of one of the specimens formed by uniting gun-wires with bronze, and subsequently turning them to a suitable shape. The squares on the end view show the arrangement of the wires. Brazing was effected without the use of a flux, on the principle of the process employed in the fabrication of guns.

MEASUREMENTS.

The measurements of the specimens were taken with instruments made by Messrs. Brown & Sharpe, of Providence, R. I., (with a little adaptation,) and verified by comparison with standards. They were read directly, by means of verniers, to $\frac{1}{1000}$ of an inch. In order that the instrument for measuring length could be applied with more delicacy and accuracy, it was suspended, and its weight balanced by a counterpoise. The measurements were nearly all made by Mr. William F. Dove, and carefully verified by the writer until Mr. D.'s care and accuracy were fully established.

The instruments being of steel, the rate of expansion by heat must have agreed with that of the specimens so closely, that the slight changes of the temperature of the place of experiment could have had no appreciable effect, but the temperature of the instrument and specimen were almost necessarily different, as the one was affected by the heat of the hand and the other, in a greater degree, by the action of the force applied.

Errors of observation probably rarely equaled $\frac{1}{1000}$ of an inch; but the combined errors, including friction and differences of temperature, could not be limited to that amount.

TORSIONAL TESTS.

It was considered desirable that each coil of wire designed to enter into the structure of a gun should be separately tested, on account of the variability of steel made under circumstances, apparently to the manufacturers, as nearly identical as could be secured. To accomplish this by any available apparatus for tensile tests would have required the expenditure of much labor and a very considerable amount of steel. About two feet of length are required for a suitable tensile specimen of wire, while three inches suffice equally well for a torsional test, and the labor involved is much less. Principally, for these reasons, a torsional testing-machine was designed and constructed. Though it may not be easy to predict from either a torsional or tensile experiment precisely what may be the results of the other, the two methods give results easily comparable, torsional resistance in one representing tensile resistance in the other, and torsion representing extension.

It rarely happens that a tensile specimen is reduced in size in all its parts with anything like uniformity, so that its capability of elongation is far from being exhausted, and the final elongations in different experiments of the same material do not show a close correspondence. The reduction of size at the place of fracture affords probably a better basis for comparisons, but the torsional machine is believed to give more uniform results, with the same degree of uniformity in the conditions. From the greater facility with which small changes in the specimen may be observed by its use, it has special advantages in ascertaining the altered condition of the metal consequent on the strains applied.

The tables of experiments on reversed torsion and on the development of elastic resistance and resilience will illustrate this remark.

DESCRIPTION OF TORSIONAL TESTING-MACHINE.

The torsional testing-machine employed is represented in plate 1.

Two sliding heads, A and B, are fitted to a bed-piece, C, one of them carrying the parts concerned in applying the strain and measuring the extent of torsion, and the other the means of determining the force applied.

The head A bears a hollow shaft, D, mounted like the spindle of a lathe, and rotated by means of a worm-wheel, E, and endless-screw, F, the latter operated by a crank turned by hand. One hundred turns of the crank give one rotation to the wheel. For convenience of operation, the screw may be slid out of gear with the wheel by an endwise motion in the reverse direction from that to which it tends when applied to work.

A circle on the face of the worm-wheel is divided into one hundred parts, and, with the aid of a vernier, G, the extent of its rotation may be read directly to $\frac{1}{1000}$ part of a revolution. One end of the shaft D is fitted for the reception of clamp-pieces, H and I, to take hold of the specimens to be tested. They are held in place and closed upon the specimen by means of screws J and K.

The head B bears a graduated lever, L, attached to a rocking-shaft, M, (hollow and partially cut away,) so as to oscillate in a manner that will be readily understood from inspection of Fig. 6, on fine pivots *p p*, hardened and polished. The shaft to which the lever is attached is fitted with clamp pieces and screws in the same manner as the shaft D. N is a wrench for operating the screws. A weight, O, slides upon the lever, its movement through the whole length of the scale, which is divided into one hundred parts, indicating a difference of one pound at the distance of one foot from the center of motion, a distance to which all the strains are referred. The lever and sliding weight, when at zero, are balanced by the counterpoise P. From the outer end of the lever are suspended, from knife-edges, in a manner that need not be particularly described, additional weights, as required. These weights are represented in Figs. 7 and 8.

An arm, Q, projecting from the head B bears, at its outer end, a loop, R, through which the lever passes, and by which its motion is restrained to narrow limits of oscillation. A scale is sometimes attached to the loop for reading small variations in the position of the lever.

By sliding the heads upon the bed-piece, the clamps may be brought together or separated to the distance of about 12 inches, the machine thus accommodating itself to specimens of various lengths. Its capacity is not intended to exceed the test of steel specimens of one-half inch in diameter.

ANNEALING.

In order that the distinctive properties of specimens of steel may be ascertained and compared, it is necessary that they should be brought to occupy some common level of condition before the application of mechanical tests, a state which is best secured by uniform annealing. This process, as usually conducted, subjects the pieces to superficial oxidation and consequent removal of at least some small proportion of carbon from the exterior part. It becomes necessary, therefore, to give the specimens protection during the process. This has been done by surrounding them, when heated and while cooling, with a mixture of cast-iron borings and sesquioxide of iron. This mixture is employed not only to guard against oxidation, but to prevent the absorption of carbon, which there seems reason to suspect in the use of the cast-iron borings alone.

It is assumed that the action of any carbonic oxide or other carburizing gas, which might be formed in the process, would be expended in the reduction of the finely-divided oxide rather than upon the inclosed steel. As a further precaution, to prevent the injurious presence of sulphur derived from the oil with which such borings are liable to be contaminated, even when it would not be suspected from their appearance, they are kept at a red heat for some time, and cooled without access of air, before being employed in annealing. Any sulphur remaining after the decomposition of the oil would be speedily absorbed in the production of sulphide of iron.

The proportion of oxide mingled with the borings is about as one to ten by weight.

The specimens, surrounded with the mixture, are inclosed in a wrought-iron tube having one open end, which is closed by an iron plug after the tube is charged. The plugged end is heated a little in advance of the other and cooled a little later. The whole tube is brought, as evenly as possible, to a bright-red heat, and maintained there long enough to insure a nearly equal temperature to its contents. It is then removed from the furnace and buried in pulverulent lime, which so well retains the heat, that at the expiration of sixteen hours it is found too hot for the hands.

At first the eye was depended on for determining when the proper heat had been reached, but a means of greater certainty was soon employed. Little tubes, generally made by drilling a piece of gun-wire, were prepared, the open end being fitted with a tight screw-plug. These were charged with pieces of alloy or metal of different fusibilities and inclosed in contact with the specimens. If, after annealing, the more fusible alloy was found to have been melted, while the other had not been, it was evident that the heat had been limited to the interval between the two melting-points. The standard of heat adopted was between the melting-points of copper and of an alloy composed of five parts of copper to one of tin. When a bundle of specimens were annealed together, the more fusible metal was placed in the center and the less on the outside; if the specimens were of considerable length, two or more sets of heat-tests were employed. After all the experience obtained with the aid of such guides and the most favorable conditions, a skillful workman sometimes failed to judge correctly of the heat, and if either the copper was found melted or the bronze unmelted, the specimens were not accepted for tests comparing qualities.

In the tables considerable matter will be found bearing upon the effects of annealing at different heats.

Too many of the tests of steel on record have been made without regard to previous mechanical treatment, and their value as a means of comparing the different methods of manufacture, or, when taken alone, of indicating the real quality of the material experimented on, is therefore very small. This fact is mentioned because surprise may be felt by some in noticing that in the following tables of tensile tests the breaking-strains, estimated upon the original area of cross-section, are not as great as they are accustomed to see given in tables of the strength of materials, an observation which holds good, not only with regard to the low steels in which cohesive strength is designedly relinquished in some degree for the sake of greater extensibility, but also as regards the "tool-steels" of higher carburization. As sent from the works, bars of tool-steel are *hammer-hardened* in various degrees, by which their tensile resistance is increased at the expense of their extensibility, and in this condition, usually, the tests have been applied. Another cause has contributed to error in stating the strength of materials. The form of specimen often used, in which only a very short part was reduced to the diameter measured, give a higher breaking-strain than a cylindric or prismatic form.

The considerations which make it desirable that tests of pieces of construction should be made upon specimens of the full size of the work also lead to the desirableness of ascertaining the distinctive qualities of materials from specimens of small size, in which internal conflicting strains, incident to a variety of causes affecting large pieces, are easily avoided.

GUNPOWDER TESTS.

It was considered important to ascertain the effects of strain applied with the rapidity of the action of gunpowder upon the extensibility of specimens of gun-wire compared with those resulting from the strains applied by means of testing-machinery. How far the well-known property belonging to some other materials, of changing their form readily under moderate continued force, while they manifest great brittleness if the rupturing strain be quickly applied, might be found to belong to the steel examined, could be determined only by experiment. That ordinary steels manifest this property under the action of blows, was well known. To test representative specimens of the wires in respect to the quality referred to, an apparatus was prepared in which the strain upon the wire was exerted by the explosion of a charge of gunpowder. It is represented in plate 5. A is a hollow steel cylinder, within which the explosion takes place. The specimen to be tested, D, lies centrally in the bore, and is grasped at the ends by clamps B and C, (represented on a larger scale in Figs. 2 and 3,) which have an exterior cylindric surface, fitted loosely to the bore. The wedges *a* and *b*, between which the specimen D is pinched within the clamps, are closed upon it, as a result of their inertia, at the first moment of firing, and by the pull upon the specimen.

The charge of powder employed was inclosed in a light paper box, its ends being perforated to allow it to slide into position on the specimen, and its sides punctured to admit the flame from an ordinary primer. The inner portion of the vent *e* was reduced to a diameter of one-tenth of an inch. Gas-checks, of which one is shown in section at *ff*, Fig. 2, were provided to prevent escape of gas, either at the sides of the bore or about the specimen being tested. The cylinders D and E (fortunately found among old material) were filled with sand (retained in place by light boards *g h*) and employed to receive and arrest the clamps and fractured specimens after the explosion.

After the first few experiments, which evinced an unexpected degree of extensibility in the specimens, it was thought desirable to ascertain, with such degree of approximation as might be readily secured, the strains by which the work was effected. For this purpose the arrangement represented in full size in Fig. 4 was provided. A is the section of a portion of the cylinder within which the explosion takes place, drilled and tapped to receive a piston, F, and screw-plug G, between which is placed, previous to each discharge, a "pressure-disk," H. A ring of leather, occupying the groove *n*, forms the requisite packing for the piston.

The outer end of the piston is conically concave, the surface of the concavity being chased to form helical threads of $\frac{1}{80}$ of an inch pitch from center to circumference, and divided radially into ten equal parts. One of the dividing-lines is enough heavier than the others to be easily distinguished.

The disks which receive and record the pressure are made from metal first drawn into wire three-eighths of an inch in diameter, and afterward cut and finished in a lathe to the thickness of 0″.125.

The figure at J is intended to represent the arrangement of the lines on the outer end of the piston, and K an impression upon one of the disks.

When the piston is forced upon them, they yield to the pressure to an extent indicated by the number of turns of the helical thread imprinted upon them, from which may be read the indication of pressure.

The arrangement may be designated a modification of Lieutenant Metcalfe's modification of the Rodman pressure-gauge.

Three materials were separately used for the disks: copper, an alloy of zinc and tin, and tin alone.

From imprints of the piston on disks pressed in the testing-machine with given weights, curves were constructed in which the pressures were taken as abscisses and turns of the helices impressed as ordinates. These were used in reading the indications of pressure in the experiments with gunpowder. Copies of the curves are given in plate 6, the curve for copper being a part of one of greater extent, afterward verified and much used in taking pressures in experiments of a different character.

A comparison of the results obtained with disks of different materials seems to indicate that the question of time in the duration of pressures enters more largely into the results with some metals than with others. It would appear probable that copper approaches a true indication much more nearly than tin.

EXLANATION OF MARKS APPLIED TO DESIGNATE THE MATERIAL OF SPECIMENS.

HWco. All the specimens bearing this mark were produced by Messrs. Hussey, Welles & Co., and all were furnished by them in the form of rolled wire rods three-eighths of an inch square, with the exception of one bearing the mark of **HWcoT**, a $\frac{3}{8}$-inch square hammered bar of the "best" tool-steel, procured at their Philadelphia agency.

BA to **CE**. The specimens marked with two large letters, (without the addition of the small ones, "co,") in alphabetical succession, between and including **BA** and **CE**, are also of their production, and were furnished upon an order for a sample of 1,000 pounds, to be as nearly as possible like the selected specimen **HWco 4**.

CM to **CV**. These letters designate ten rolled $\frac{3}{8}$-inch square rods, representing as many meltings, afterward furnished by them, and intended to be alike and of the average quality of the 1,000-pound sample.

DL to **DP** were subsequently furnished by the same firm, and specimens of the same metal were also marked, in the same order, **HWco**, with the addition of the numerals 8, 9, 10, 11, and 12.

Another lot, containing eight samples, was marked **HWco**, with the numerals 13, 14, 15, 16, 17, 18, 19, and 20. Like the preceding, they were intended to be of the average quality of the 1,000-pound sample.

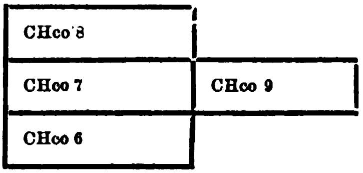
All these samples were of the kind called "crucible steel," the carburization of the iron being effected within the crucible at the time of melting.

CHco, in every instance but one, (when the mark **CHco 5 I** is used to designate a quality of iron made by the Trenton Iron Company, and called by them "gun-screw iron,") is used to designate "Martin steel" manufactured by the New Jersey Steel and Iron Company. Specimens numbered 1, 2, 3, and 4 were of varying qualities, furnished to afford opportunity for selection.

A to **AP**, The specimens bearing these letters and those between them in alphabetical order were also of Martin steel, the production of the same company, and were furnished upon an order for 1,000 pounds, to be of the same quality as the selected specimen designated **CHco 4 S**.

The specimens marked **CHco** with the addition of the numerals 6, 7, 8, and 9 were made from different parts of a *sprue* examined to ascertain whether specimens taken from the parts of the castings, so called, could be made available for determining with sufficient accuracy the properties of the "charge" of steel which they might represent.

These sprues are the metal filling the side runners connecting a "group" of ingots at the bottom with the central runner, through which the pouring is made. They are approximately 2¼ inches square, curved in form, and the portion furnished about 5 inches long. The sprues are generally more porous than the ingots with which they are cast, and for that reason the question of how far they might furnish means of ascertaining the quality of the ingots was one of doubt. The porosity of this sprue was chiefly central and inclining to the upper side. In forging the rods preparatory to drawing into wire, the sprue was first flattened from above downward into a bar about 3″ x 1″. About three-fourths of this was slitted into three bars about 1 inch square, and the remainder drawn into a bar of the same dimensions. After close examination and the removal of all visible defects or flaws, they were reduced to wire rods three-eighths of an inch square and drawn into wires of the usual size. The diagram below will indicate to what portions the several marks were applied.



The bar marked 7 would, of course, be formed of the most porous portion of the sprue, 6 and 8 of the least porous, and 9 would represent the whole.

CF to **CK** designate specimens of Martin steel, from the same source, rolled to ⅜-inch-square wire rods, from ingots cast from three "charges," each of which was poured to form two groups of ingots. The letters were applied as follows:

CF to the specimen from the first group, first charge.
CG to the specimen from the second group, first charge.
CH to the specimen from the first group, second charge.
CI to the specimen from the second group, second charge.
CJ to the specimen from the first group, third charge.
CK to the specimen from the second group, third charge.

CL was supposed to have been taken from the lowermost part of the ingot from which **CF** was taken at the top. Its characteristics make it evident that some mistake as to its identity must have occurred.

Specimens marked **CHco SprG**, with the addition of two numerals, were specimens prepared from six different sprues from the same "charge" or melting. The first added numeral refers to the group of ingots from which the piece was taken; the second to the number of the specimen from that group. The groups were poured in the order of the numbers given. These sprues were forged entire; that is, without slitting.

SPR with a numeral always designates steel produced by the New Jersey Steel and Iron Company, the specimen being part of a sprue forged entire, and reduced to a wire rod, with care to secure the most perfect specimen procurable from it.

The relation of the **SPR** numbers to the "charges" and "groups" with which they were connected will be readily seen by inspection of the subjoined table:

Charge.	Group.	Sprue numbers.	Charge.	Group.	Sprue numbers.	Charge.	Group.	Sprue numbers.
838	1	1-2	891	1	37	899	1	57
	2	3-4		2	38	900	1	58
	3	5-6	889	1	39	890	....	59
842	1	7-8		2	40	896	....	60
	2	10-11		3	41	917	1	61
	3	12-13	892	1	42		2	62
844	1	14-15		2	43		3	63
	2	16-17	894	1	44	918	1	64
	3	18-19		2	45		2	65
845	1	20-21	895	1	46		3	66
	2	22-23		2	47	919	1	67
848	1	24-25	896	1	48		2	68
	2	26-27		3	49		3	69
	3	28-29	897	1	50	920	1	70
852	1	30-31		2	51		2	71
	2	32-33						
	3	34-35						

EF designates a specimen of Martin steel from the New Jersey Steel and Iron Company, made principally from "Bessemer scrap," from the production of the works of the Pennsylvania Steel Company.

CSco, with numerals 5, 6, 7, and 8, designate "Chrome steel," made and furnished by the Chrome Steel Company, the several numerals indicating different meltings, intended to be of the same quality.

The higher numerals designate specimens subsequently furnished, intended to combine as much as possible the quality of high cohesive strength with large extensibility, and to be alike in quality.

The specimens marked **CHROME** were taken from a bar marked "No. 3," which had been procured from the same company for use in the ordnance-shops at the Washington navy-yard.

Nco I designates specimens made from the same bar of Norway iron, of the brand *HΦΣ*, furnished by Messrs. Naylor & Co.

Nco 1 S, with a letter in brackets, designates six wire rods furnished by Messrs. Naylor & Co., made and imported as a specimen intended to combine in the highest degree the properties of strength and extensibility. They are distinguished individually by the different added letters.

Nco T designates specimens of "best cast-steel," (or tool-steel,) furnished by the same firm. All the specimens are understood to have been produced by cementation before fusion.

PBco 1 designates a specimen of the so-called "German steel," rolled to ⅝-inch square from a cemented bar not afterward melted, furnished by Messrs. Park, Brother & Co.

PBco, with other numerals, designates cemented cast-steel, designed to be alike and of the best quality, rolled ⅝ inch square, furnished by the same firm.

Ccb, numbers 1 to 10, designate a set of specimens of cemented steel received as ⅝-inch square hammered bar, from Messrs. Miller, Barr & Parkin, intended to be alike and of the best quality.

The letters **DV**, **DW**, **DX**, **DY**, and **DZ** designate specimens designed to be alike, (also in some specimens marked **Cco 11-15**, in the same order,) and **EA**, **EB**, **EC**, **ED**, and **EE** (also marked **Cco 16-20**) were rolled wire rods from the same firm.

CRESCENT is a specimen of tool steel made by the same parties, but not furnished directly by them.

Tco, with added numerals, designates specimens of crucible steel, furnished as wire-rods ⅜ inch square, by Messrs. J. R. Thompson & Co. Nos. 1 to 10 were stated to be each of a different quality. Nos. 11 to 16 were subsequently furnished, and were intended to be alike.

NSco designates specimens of crucible steel furnished by Messrs. Benj. Atha & Co. The first five numbers were designed to be all different. **NSco** 1 differs from the others in being made from a cheaper stock. Nos. 2, 3, and 4 were intended to differ in the amount of carbon only.

A second lot took the Nos. 6, 7, and 8; 6 was their ordinary tool-steel; 7 and 8 were of cheaper stock, 7 being lower in carburization, and 8 still lower.

The third lot contained four samples, designed to be an improvement on **NSco** 7, and all alike. They were numbered from 9 to 11, inclusive.

Aco. This is the designation of samples of crucible steel furnished by A. C. Lewis, manager of the Atlantic Steel Works. The first lot consisted of ten ⅜-inch square wire rods, rolled from as many ingots. They were intended to be alike in quality, and to meet the results of the tests of other approved samples, as nearly as might be, on first trial. They were marked with numbers added from 1 to 10. The next lot of samples contained 30 rods, rolled as before, each the product of a different melting. They were classed in three grades, bundled separately, the rods in each bundle intended to be alike. The rods in bundle I were marked Aco, with added numerals 12 to 21, inclusive; in bundle II, 32 to 41, inclusive; and bundle III, 22 to 31, inclusive.

Following this, another lot, containing 43 rods, was furnished, representing as many meltings. They were in two bundles, but not separated as to grade. They were numbered from 42 to 84, inclusive.

A subsequent lot, divided into five grades, was marked with numerals as below:

Grade 1, 85 to 95.
Grade 2, 96 to 106.
Grade 3, 107 to 127.
Grade 4, 128 to 137.
Grade 5, 138 to 147.

ASco designates a single specimen of cast-steel furnished by the Aultman Steel Company.

BSSB and **BSco**, with added numerals, designate several samples of "open-hearth" steel, furnished by manufacturers who, at the time, desired not to have their names mentioned in connection with them.

Mco designates samples of "open-hearth" (or Martin) steel produced at the Midvale Works, and furnished by the proprietors in the form of rolled ⅜-inch square rods.

No. 1 was a specimen of low steel, such as they were constantly producing for the ordinary uses of that material. Nos. 2 and 3 were furnished afterward.

No. 2 bore the stamp of one star, and was stated to be "low in carbon." No. 3 was marked with two stars, and was stated to contain more carbon than the former, but otherwise to be of the same metal.

BEs, with numerals, designates specimens of Bessemer steel procured at the works of Messrs. John A. Griswold & Co. They were short bars, hammered to about three-fourths of an inch square. The portions reduced to wire were first hammered to ⅜-inch square rods.

SBco is applied to two ⅜-inch hammered bars of Messrs. Sanderson Bros. & Co.'s "best cast-steel," (tool-steel,) of English manufacture; procured at their agency in Philadelphia. The bars are marked, respectively, **SBco 1** and **SBco 2.**

HEco designates two ⅜-inch square hammered bars of "best cast-steel," (tool-steel,) English, the production of Messrs. Wilson, Hawksworth, Ellison & Co., numbered, respectively, 1 and 2.

Jco designates two bars, ⅜-inch square, hammered "best cast-steel," (tool-steel,) produced by the English manufacturers, Messrs. Wm. Jessop & Sons, numbered 1 and 2.

FMco is the mark applied to two ⅜-inch square hammered bars of "best cast-steel," (tool-steel,) English, made by F. W. Moss, and, like the other English specimens, procured from the manufacturer's agents.

JBHco designates a specimen, procured in the form of a 1¼-inch square bar, of Prussian steel, the production of Messrs. J. B. Haseclever & Sons, procured through their agent in Philadelphia. It is a so-called "natural steel," imported under the name of "double-refined wedge" steel, under the impression of its being of very superior quality. The portion drawn into wire was first hammered to three-eighths of an inch square.

Hco is the mark borne by two specimens of steel known as "Hobson's Choice." They are of English manufacture, produced by Messrs. Francis Hobson & Son, and procured from their agent for use in the ordnance shops at the navy-yard. Both bars bore the brand

CHOICE (XX) EXTRA.

Specimens marked **I&Ssc** and **I&Sic** were composed of iron and chrome steel united. The rods from which the wires were drawn were formed by welding together in square form, in angular swages, nine wires 0".3 square, and afterward drawing them under the hammer to the proper size. In one case the central wire and the four at the corners were of steel. The specimen so produced was marked **I&Ssc.** In forming the other, iron wire occupied the center and corners of the welded piece. The relative position of the iron and steel portions of the finished wire is shown in the sections Figs. 8 and 9, Plate 4.

The specimens of wires not bearing the mark of a star in addition to the other designating-mark were drawn by the Trenton Iron Company in the ordinary way, passing through the processes of annealing and pickling. The superficial portions of such wires were found partly decarburized, a result manifested on breaking a hardened piece, when the parts would often be held together by a very thin *skin* of soft metal.

As an economy of time, tools for drawing wires of moderate length were attached to a strong planing-machine, which furnished the necessary power, and used in the preparation of many of the specimens tested. The rods to be drawn were first deprived of scale and oxide by means of an emery-wheel, and then annealed in the manner described as being employed with finished specimens, which rendered pickling unnecessary. Annealing after drawing was conducted in the same way. All specimens drawn in this way have a star stamped on them to indicate the fact.

In a few instances the annealing of tested specimens was not done at the "standard heat," (between the melting-points of bronze and copper,) and in such cases the marks LH or CH are applied. The former signifies that the heat did not melt bronze, and the latter that copper was melted. In either case the heat approximated the mean of the two as nearly as the workman was able to determine by the eye alone.

CHANGES IN SPECIMENS UNDER TENSION.

The order of the phenomena of the changes produced in a specimen of extensible metal under tension slowly applied may be given, in a general way, as follows:

1st. Extension within the elastic limit.

The *precise* limit of the extension from which a specimen will perfectly recover itself, on release, it is impossible to ascertain, as the limit, either of strain or extension, can only be recognized by passing it.

Within those limits the continuance of strain does not result in appreciable permanent change, at least within moderate periods of time.

2d. Extension beyond the elastic limit, permanent elongation, and extension of the elastic limit of strain.

The time for which the strain is continued is an important factor in these results.

With increase of strain these changes are manifested in increased degree within bounds varying with the material experimented on, the strains sustained increasing with greater proportionate rapidity than the elongations they produce.

These changes lead to a condition—

3d, in which the specimen as a whole sustains the greatest strain of which it is capable, and in which a definite minute increment of strain reduces the area of its cross-section in sensibly the same proportion.

The point of its occurrence can, of course, only be known by passing it.

4th. Under the continuance of the same strain the area of the cross-section of the specimen is more or less rapidly reduced until rupture occurs.

This reduction of area is attended with an increase of strength regarded in relation to the decreased area, an increase which may, under favorable circumstances, be approximately measured.

The strain at which rupture actually occurred in these experiments is designated as "*parting strain*," the words "*breaking strain*" having been commonly employed to denote the highest strain sustained by a specimen.

TABLES OF TENSILE TESTS.

Some general explanations of these tables may be necessary.

The *strains* were applied in the order presented; the greatest strain given being the highest strain the specimen was found to sustain.

The strains following this were observed in the course of the diminution of the area of section occurring after passing the highest strain.

The last one given is the "parting strain," that at which actual rupture occurred.

The *time* given in connection with the strains includes that in which the increase of strain was applied, together with the time for which the given strain was continued to produce the given elongation, unless otherwise noted.

The *elongation* recorded is that produced by the given strain continued until its maximum effect had been *very nearly* reached, except when otherwise stated.

TABLE 1.—*TENSILE TESTS of square gun-wires of various manufacture*—Continued.

Mark on specimen designating—		Strain.		Elongation under strain.			Elongation after release.			Resilience.			Dimensions of cross-section.				Strain per square inch.		Elastic limit of strain compared with highest strain.	Remarks.
No. of experiment.	Material.	On specimen.	Time of application.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	Original.	Under strain, (smallest place.)	Released, (smallest place.)	Percentage of original area.	Of original area.	Of reduced area.		
		Lbs.	*m. s.*	*In.*	*In.*		*In.*	*In.*		*In.*	*In.*		*In.*		*In.*		*Lbs.*	*Lbs.*	*Per ct.*	
10	C H co 4 s	1,500	2 05	0.000									.2915 x .2975							
		2,000	1 25	0.000																
		2,500	2 00	0.000																
		3,000	1 35	0.007		.07				0.007		.07								
		3,500	1 25	0.015		.15	.000			0.015		.15								
		4,000	1 30	0.015		.15	.000			0.015		.15					46,130			
		4,500	9 50	0.103		1.03	.079		.79	0.024		.24					51,896			
		7,980	9 30																	
		8,300	5 00														95,719		50.602	
		7,670	1 25																	
		7,450		Broke				.707	14.14						.234 x .235	63.41		135,479		
11	C H co 5 I	1,000	2 35	0.000									.291 x .292							
		1,500	1 50	0.000																
		2,000	2 25	0.010		.1	0.000			.010		.1					23,537			
		2,500	27 10	0.157		1.57	0.145		1.45	0.012		.12					29,421			
		4,000	5 50				0.879		8.79											
		4,300	4 25				1.620		16.20											
		4,470	5 30											.220 x .225		59.84	52,605	87,925	48.098	
		4,050	2 30																	
		3,500		Broke				1.056	21.12						.1913x.1895	42.24		40,218		
12	C S co 5	1,500	1 05	0.000									.295 x .297							
		2,000	1 00	0.000																
		2,500	1 30	0.004		.04	0.000			0.004		.04								
		3,000	1 30	0.011		.11	0.000			0.011		.11								

		3,500	2 50	0.012		.12	0.000			0.012		.12					39,947		
		4,000	23 00	0.066		.66	0.050		.5	0.016		.61					45,665		
		7,600	14 20																
		7,800	4 40														89,025		47.436
		7,125												.247 x .2505		70.62		115,154	
		6,780		Broke			.905		9.05						.228 x .228	59.33		130,424	
13	C S 6	1,500	2 15	0.000									.2955 x .2935						
		2,000	1 00	0.000															
		2,500	1 30	0.000															
		3,000	3 40	0.002		.02	.000			0.002		.02					34,590		
		3,500	17 30														40,355		
		3,500	46 40	0.050		.5	.035		.35	0.015		.30							
		6,600	10 00																
		6,740	4 00														77,713		
		5,975												.236 x .236		64.22		107,278	
		5,950	1 00	Broke				.316	6.32						.225 x .227	58.89		116,495	
14	C S co 7	1,500	2 15	.000									.295 x .293						
		2,000	1 00	.000															
		2,500	1 40	.005		.05	.000			.005		.05							
		3,000	3 00	.011		.11	.000			.011		.11					34,708		
		3,500	51 00	.154		1.54	.140		1.4	.14		.14					40,492		
		5,950	6 00																
		6,200	8 00														71,730		50.000
		5,550	1 30											.238 x .242		66.64		96,360	
		5,350		Broke				.710	14.20						.218 x .220	55.49		111,551	
15	C S co 8	1,500	2 00	.000									.294 x .296						
		2,000	1 30	.004		.04	.000			.004		.04							
		2,500	3 45	.008		.08	.000			.008		.08							
		3,000	4 00	.008		.08	.000			.008		.08					34,468		
		3,500	7 00	.016		.16	.009		.09	.007		.07					40,213		
		7,125	8 05																
		7,625	8 00																
		7,750	3 00														89,043		45.161
		7,450	2 00																
		6,750	1 00	Broke			.865		8.65						.225x .2265	58.56		132,450	
16	N co I	1,000	2 00	.000									.2895 x .2925						
		1,500	3 10	.000															
		2,000	7 30	.005		.05	.000			.005		.05					23,618		
		2,500	24 10	.257		2.57	.244		2.44	.013		.13					29,523		
		3,640	6 50																
		4,000	4 30																
		4,050	3 15														47,828		54.321
		3,750												.223 x .225		79.52		74,738	
		2,750	2 50	Broke				1.427	28.54						.158 x .161	30.40		40,838	

TABLE 1.—*TENSILE TESTS of square gun-wires of various manufacture*—Continued.

Mark on specimen designating—		Strain.		Elongation under strain.			Elongation after release.			Resilience.			Dimensions of cross-section.				Strain per square inch.		Elastic limit of strain compared with highest strain.	Remarks.
No. of experiment.	Material.	On specimen.	Time of application.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	Original.	Under strain, (smallest place.)	Released, (smallest place.)	Percentage of original area.	Of original area.	Of reduced area.*		
		Lbs.	*m. s.*	*In.*	*In.*		*In.*	*In.*		*In.*	*In.*		*In.*		*In.*		*Lbs.*	*Lbs.*	*Per ct.*	
17	P B co I..	1, 500	5 05	.004		.4	.000			.004		.4	.293 x .294				17, 413			
		2, 000	13 25	.017		1.7	.010		.1	.007		1.6					23, 217			
		3, 950	8 00																	
		4, 200	4 15																	
		4, 450	1 00														51, 658		44. 494	
		3, 000	25	Broke			.710		7.1						.225 x .221	57. 72		72, 400		
18	P B co 2..	1, 500	2 20	.000									.301 x .3035							
		2, 000	1 20	.002		.02	.000			.002		.02								
		2, 500	2 05	.007		.07	.000			.007		.07								
		3, 000	9 25	.011		.11	.000			.011		.11					32, 839			
		3, 500	12 25	.167		1.67	.151		1.51	.016		.16					38, 312			
		5, 600	5 00																	
		5, 640	2 00														61, 739		54. 965	Broke ¾ inch within the clamp.
		4, 875												.227 x .227		56. 40		94, 000		
		4, 825	40	Broke				.360	7.20						.210 x .210	48. 27		109, 410		
19	P B co 3.	1, 600	4 00	.010		.1	.000			.010		.1	.299 x .300							
		2, 000	1 45	.013		.13	.000			.013		.13					22, 296			
		2, 500	13 15	.016		.16	.003		.03	.016		.16					27, 870			
		4, 875	5 00																	
		5, 175	3 30														57, 692		48. 300	
		4, 700	2 00											.2475 x .2440		67. 32		91, 297		
		4, 500	1 40	Broke				.329	6.58						.211 x .214	50. 34		99, 658		

TABLE 2.—*Principal results of tensile tests of gun-wires drawn by the Trenton Iron Company from rods three-eighths of an inch square, furnished as specimens by their manufacturers. (First collection.)*

[All the specimens were annealed at a bright red heat, without oxidation, but before the application of heat-tests.]

Description of material.	Mark on specimen, designating—		Original dimensions of cross-section.	Approximate elastic limit of strain.		Elongation within the elastic limit.		Highest strain sustained.		Permanent elongation after fracture.			Measurements of area of fracture.	Area of fracture compared with original section.	Parting strain.		Elastic limit of strain compared with highest strain.
	No. of experiment.	Material.		On specimen.	Per square inch of original section.	In 10 inches of original length.	Percentage of original length.	By specimen.	Per square inch of original section.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.			On specimen.	Per square inch of area of fracture.	
			Inches.	*Pounds.*	*Pounds.*	*Inches*		*Pounds.*	*Pounds.*	*Inches*	*Inches*		*Inches.*	*Per ct.*	*Pounds.*	*Pounds.*	*Per ct.*
Crucible steel, manufactured by Messrs. Hussey, Welles & Co.	2	H W co 4	.305 x .295	3, 700	41, 122	.025	0. 25	8, 300	92, 247	.583	......	5. 83	.225 x .221	55. 27	7, 300	146, 080	44. 58
Do	3	H W co 5	.300 x .299	2, 400	26, 755	.025	.25	4, 550	50, 724	......	1. 092	21. 84	.172 x .172	32. 98	3, 100	104, 800	52. 74
Do	5	H W co 6	.2995 x .2995	3, 000	33, 953	.022	.22	5, 450	61, 685	......	.805	16. 10	.187 x .197	41. 07	4, 050	109, 960	55. 05
Do	6	H W co 7	.300 x .3025	3, 600	39, 669	.018	.18	6, 500	71, 625	......	.746	14. 92	.230 x .235	59. 56	Lost ..	....	55. 38
Martin steel, manufactured by the New Jersey Steel and Iron Company	7	C H co 1 S	.2955 x .2955	3, 700	42, 258	.022	.22	6, 300	72, 148	......	.866	17. 32	.221 x .219	53. 96	5, 050	104, 360	58. 7
Do	8	C H co 2 S	.2915 x .2925	3, 200	37, 530	.016	.16	6, 120	71, 780	2. 150	......	21. 50	.215 x .215	54. 21	5, 000	108, 180	52. 29
Do	9	C H co 3 S	.293 x .296	3, 400	39, 203	.016	.16	6, 200	71, 490	......	.893	17. 96	.215 x .217	53. 79	5, 300	113, 610	54. 84
Do	10	C H co 4 S	.2915 x .2975	4, 300	49, 020	.024	.24	8, 300	94, 618	......	.707	14. 14	.234 x .235	63. 41	7, 450	135, 470	51. 81
Iron, manufactured for "gun-screw wire" by the Trenton Iron Company	11	C H co 5 I	.291 x .292	2, 100	24, 714	.012	.12	4, 470	52, 605	......	1. 056	21. 12	.195 x .197	42. 52	3, 500	91, 122	46. 98
Chrome steel, manufactured by the Chrome Steel Co.	12	C S co 5	.295 x .297	3, 800	43, 371	.016	.16	7, 800	89, 025	.905	......	9. 05	.228 x .228	59. 33	6, 780	130, 430	48. 72
Do	13	C S co 6	.2955 x .2935	3, 400	39, 202	.015	.15	6, 740	77, 713	.....	.316	6. 32	.225 x .227	58. 89	5, 950	116, 510	50. 45
Do	14	C S co 7	.295 x .293	3, 300	43, 173	.014	.14	6, 200	71, 114	......	.710	14. 20	.218 x .220	55. 49	5, 350	111, 550	53. 23
Do	15	C S co 8	.294 x .296	3, 400	39, 069	.017	.17	7, 730	89, 056	.865	.....	8. 65	.225 x .2265	58. 56	6, 750	132, 460	43. 88
Norway Iron, H♁S, furnished by Messrs. Naylor & Co.	16	N co I	.2895 x .2925	2, 200	25, 980	.013	.13	4, 050	47, 827	......	1. 427	28. 56	.158 x .151	30. 40	2, 750	115, 300	54. 32
"German steel," manufactured by Messrs. Park Bros. & Co.	17	P B co 1	.293 x .294	1, 900	22, 056	.0071	......	4, 450	51, 660	......	.710	14. 20	.225 x .221	57. 72	3, 600	72, 405	42. 70
Cemented cast-steel, manufactured by Messrs. Park Bros. & Co.	18	P B co 2	.301 x .3035	3, 200	35, 087	.016	.16	5, 640	61, 738	......	.783*	15. 66	.210 x .210	48. 27	4, 825	109, 410	56. 74
Do	19	P B co 3	.299 x .300	2, 400	26, 745	.013	.13	5, 175	57, 692	......	.834†	16. 68	.211 x .211	50. 34	4, 500	101, 080	46. 38
Do	101	P B co 4	.2977 x .2985	....	....	......	.....	6, 660	74, 862	......	.973	19. 46	.244 x .244	67.	....	....	......

* Elongation taken from experiment No. 99.

† Elongation taken from experiment No. 100.

TABLE 3.—*TENSILE TESTS of square gun-wires of various manufacture.*

[Length of specimens, 1 inch between clamps. For explanation of marks designating material, see pages 136 to 140, inclusive. Annealed at bright-red heat without oxidation of surface. These specimens, from No. 20 to 87, were broken as quickly as consistent with accurate observation. The first strain given in each experiment is approximately that at which the specimen began to stretch. Elongation was not taken.]

Mark on specimen designating—		Strain.		Elongation under strain.			Elongation after release.			Resilience.			Dimensions of cross-section.				Strain per square inch.		Elastic limit of strain compared with highest strain.
No. of experiment.	Material.	On specimen.	Time of application.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	Original.	Under strain, (smallest place.)	Released, (smallest place.)	Percentage of original area.	Of original area.	Of reduced area.	
		Lbs.	*m. s.*										*In.*		*In.*		*Lbs.*	*Lbs.*	*Per ct.*
20	C S co 5	4,000	1 15										.294 x .2965						
		6,600	1 00														75,713		60.607
		4,900	1 00	Broke											.178 x .178	36.35		154,652	
21	C S co 6	3,500	30										.2935 x .295						
		6,840	4 30														78,999		51.170
		5,500	20	Broke											.198 x .200	45.74		138,888	
22	C S co 7	2,500	30										.293 x .295						
		5,200	4 30														60,160		48.077
		4,470	35	Broke											.215 x .223	55.47		93,231	
23	C S co 8	3,100	3 40										.294 x .296						
		7,100	4 20														81,028		43.662
		5,900	1 00	Broke											.217 x .210	52.36		129,471	
24	C S co 5	3,600	1 00										.295 x .2975						
		7,100	5 45														80,897		50.704
		5,750	1 05	Broke											.204 x .204	47.42		138,168	
25	C S co 6	3,400	3 00										.294 x .295						
		6,460	5 00														74,484		52.632
		5,075	45	Broke											.184 x .188	39.88		146,710	
26	C S co 7	2,800	1 30										.293 x .294						
		5,225	6 00														60,655		53.589

		4,400	50	Broke											207 x .204	40 03		104,210	
27*	C S co 8	3,810	5 00										.296 x .2925						
		7,720	6 35	Broke											.240 x .235	65.14	89,166		40.223
28	H W co 4	3,200	2 15										.299 x .300						
		6,500	6 00														72,463		49.230
		4,750	2 00	Broke											.175 x .178	34.73		152,487	
29	H W co 4	3,600	5 00										.300 x .300						
		8,400	5 15														93,333		42.857
		7,200	4 35																
		5,750		Broke											.182 x .187	37.82		168,948	
30	H W co 5	2,200	1 40										.2985 x .300						
		4,725	5 55														52,761		46.561
		3,200	50	Broke											.166 x .166	30.77		116,860	
31	H W co 5	2,000	1 10										.299 x .300						
		4,585	6 00														51,114		43.021
		3,850	2 00	Broke											.142 x .142	22.48		141,341	
32	H W co 6	2,200	2 15										.2985 x .2990						
		4,550	3 45														50,979		48.352
		2,900	1 30	Broke											.150 x .152	25.55		127,193	
33	H W co 6	2,100	1 10										.299 x .2985						
		4,600	4 30														51,539		45.652
		3,000	1 25	Broke											.142 x .143	22.75		147,739	
34	H W co 7	2,500	1 40										.305 x .2985						
		5,300	4 00														58,214		47.170
		3,200	1 10	Broke											.171 x .171	32.12		129,954	
35	H W co 7	2,400	1 30										.299 x .302						
		5,475	4 35														60.566		43.836
		3,850	1 20	Broke											.160 x .161	28.53		149,456	
36	C H co 1 S	3,810	3 30										.296 x .296						
		5,900	4 30																
		5,950	20														67,381		63.866
		4,650	1 10	Broke											.187 x .189	40.06		131,567	
37	C H co 1 S	3,700	3 50										.296 x .2955						
		5,975	5 20														67,616		61.924
		4,700	1 30	Broke											.192 x .193	39.71		134,042	
38	C H co 2 S	3,100	3 00										.2925 x .2945						
		5,340	4 30														62,455		57.621
		4,320	30	Broke											.196 x .198	45.05		111,317	

* Broke too quickly to get parting strain.

TABLE 3.—*TENSILE TESTS of square gun-wires of various manufacture*—Continued.

Mark on specimen designating—		Strain.		Elongation under strain.			Elongation after release.			Resilience.			Dimensions of cross-section.				Strain per square inch.		Elastic limit of strain compared with highest strain.
No. of experiment.	Material.	On specimen.	Time of application.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	Original.	Under strain, (smallest place.)	Released, (smallest place.)	Percentage of original area.	Of original area.	Of reduced area.	
		Lbs.	*m. s.*										*In.*		*In.*		*Lbs.*	*Lbs.*	*Per ct.*
39	C H ∞ 2 S	3,200	2 30										.2925 x .2930						
		5,775	6 00														67,382		55.411
		4,550	1 15	Broke											.199 x .199	46.21		114,896	
40	C H ∞ 3 S	3,300	2 45										.296 x .294						
		5,725	2 25														65,478		
		4,475	40	Broke											.193 x .193	42.61		120,137	57.642
41	C H ∞ 3 S	3,300	1 25										.2955 x .2945						
		6,000	5 25														69,173		55.000
		5,000	1 00	Broke											.209 x .209	50.36		112,131	
42	C H ∞ 4 S	4,000	4 20										.2935 x .2955						
		7,575	6 40														87,341		52.805
		6,450	45	Broke											.215 x .218	54.04		137,657	
43	C H ∞ 4 S	4,100	2 40										.2940 x .2955						
		8,175	2 50														94,098		50.153
		7,400	15	Broke											.230 x .232	61.42		138,680	
44	C H ∞ 5 I	2,900	3 15										.2925 x .2925						
		4,350	4 10																
		4,900	45														57,272		44.898
		3,900	15	Broke											.195 x .196	44.67		102,040	
45	C H ∞ 5 I	2,200	1 45										.292 x .292						
		4,470	3 25														59,426		49.217
		3,600	50	Broke											.191 x .191	42.79		98,684	
46	N ∞ I	2,000	4 15										.293 x .293						

		4,150 2,800	5 05 1 05	Broke													48,506		46.103
47	N co I	*2,000* *4,200* 2,700	*4 35* *5 20* 1 05	Broke									.294 x .2915		.156 x .153	27.85	49,007	113,122	47.619
48	P B co 1	1,600 3,850 2,600*	2 20 5 45 30	Broke									.2975 x .299		.216 x .218	53.05	43,281	59,337	41.588
49	P B co 1	1,900 4,525	2 55 5 25	Broke									.298 x .2975		.247 x .247	68.62	51,040		41.989
50	P B co 2	3,200 6,625 6,000	3 30 5 30 15	Broke									.3035 x .3040		.230 x .233	58.08	71,803	111,961	48.302
51	P B co 2	2,700 5,570 4,800	3 10 4 45 15	Broke									.303 x .3005		.213 x .213	49.85	61,174	105,799	48.474
52	P B co 3	2,700 5,570 4,250	2 20 4 30 25	Broke									.301 x .300		.220 x .220	55.97	61,683	102,272	48.474
53	P B co 3	3,300 6,450 6,000	4 05 5 00 25	Broke									.301 x .3005		.233 x .237		69,250	108,673	51.163
54	H W co 4	3,000 8,550	10 00 10 00	Broke									.305 x .295		.2593 x .2484		36,500 104,500		35.088
55	H W co 4	2,557 8,675	7 00	Broke									.305 x .295		.2577 x .2513	53.75	32,363 106,025		29.476
56	H W co 5	1,300 4,750 3,440		Broke									.300 x .299			30.00	14,492 52,954		27.368
57	H W co 5	1,435 4,675 3,310	4 00 2 00	Broke									.299 x .300		.1714 x .170	32.48	15,997 52,118	11,360	30.695
58	H W co 6	1,300 4,930 3,400*	6 30	Broke									.2995 x .2995		.174 x .181	35.11	14,492 54,960	10,796	26.369
59	H W co 6	1,300 4,950 3,700	5 00 2 00	Broke									.2995 x .2995		.178 x .1835	14.57	14,492 55,183	11,330	26.263

* About.

TABLE 3.—*TENSILE TESTS of square gun-wires of various manufacture*—Continued.

Mark on specimen designating—		Strain.		Elongation under strain.			Elongation after release.			Resilience.			Dimensions of cross-section.				Strain per square inch.		Elastic limit of strain compared with highest strain.
No. of experiment.	Material.	On specimen.	Time of application.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	Original.	Under strain, (smallest place.)	Released, (smallest place.)	Percentage of original area.	Of original area.	Of reduced area.	
		Lbs.	*m. s.*										*In.*		*In.*		*Lbs.*	*Lbs.*	*Per ct.*
60	H W co 7	1, 300											.300 x .3025				14, 325		
		6, 215	8 00														68, 484		20. 917
		5, 400	30	Broke											.218 x .222	53. 33		11, 134	
61	H W co 7	1, 400											.3025 x .300				15, 426		
		6, 170	4 15														66, 867		22. 690
		5, 400	30	Broke											.2275 x .220	55. 15		110, 900	
62	C H co 1 S	1, 650											.2955 x .2955				18, 895		
		6, 400	4 15														73, 293		25. 781
		5, 200	1 30	Broke											.2065 x .2065	48. 71		121, 944	
63	C H co 1 S	1, 750											.2955 x .2955				20, 041		
		6, 475	4 30														74, 152		27. 027
		5, 400		Broke											.218 x .205	49. 77		124, 254	
64	C H co 2 S	1, 700											.2915 x .2925				19, 938		
		6, 100	4 30														71, 542		27. 869
				Broke											.208 x .207	50. 50			
65	C H co 2 S	1, 400											.2915 x .2925				16, 419		
		6, 150	4 00														72, 129		22. 764
		5, 150	1 00	Broke											.208 x .210	51. 23		117, 900	
66	C H co 3 S	1, 350											.293 x .296				15, 565		
		6, 335	5 00														72, 542		21. 310
		5, 450	1 30	Broke											.210 x .211	51. 09		122, 990	
67	C H co 3 S	1, 650											.293 x .296				18, 894		
		6, 250	4 00														71, 569		26. 400
		5, 500	1 00	Broke											.210 x .215	51. 70		12, 181	

68	C H co 4 S	1,550											.2915 x .2975				17,880		
		8,170	4 30														94,209		12.972
		7,570	30	Broke											.241 x .241	66.97		13,133	
69	C H co 4 S	1,650											.2975 x .2915				19,026		
		8,170	4 15														94,209		20.196
		7,620	45	Broke											.240 x .240	66.42		13,220	
70	C H co 5 I	700											.291 x .292				8,238		
		4,450	4 15														52,370		15.730
		3,600	45	Broke											.190 x .190	42.48		99,723	
71	C H co 5 I	850											.291 x .292				10,003		
		4,490	3 15														52,340		12.931
		3,600	45	Broke											.187 x .1925	42.36		100,000	
72	C S co 5	1,550											.295 x .297				17,691		
		8,100	4 00														92,449		19.137
		7,650	30	Broke											.243 x .248	70.20		124,380	
73	C S co 5	1,450											.295 x .297				16,549		
		7,650	3 00														87,313		18.954
		6,870	30	Broke											.235 x .227	60.89		128,780	
74	C S co 6	1,600											.2955 x .2935				18,469		
		7,030	3 30														81,150		22.760
		6,660	15	Broke											.237 x .243	66.40		115,640	
75	C S co 6	1,650	4 00										.2955 x .2935				19,046		
		7,180	30														82,881		22.981
		6,800		Broke											.236 x .249	67.76		115,710	
76	C S co 7	1,250											.295 x .293				14,461		
		5,950	3 00														68,847		21.008
		5,450	45	Broke											.233 x .230	62.00		101,690	
77	C S co 7	1,350											.295 x .293				15,618		
		6,000	3 30														69,416		22.500
		5,430	30	Broke											.226 x .231	60.40		104,010	
78	C S co 8	1,400											.294 x .296				15,976		
		7,600	4 00														86,73[illegible]		18.421
				Broke											.246 x .247	69.82			
79	C S co 8	1,450											.294 x .296				16,547		
		7,400	3 45														84,565		19.595
		7,180	30	Broke											.248 x .250	71.24		115,800	
80	N co I	750											.2895 x .2925				8,857		
		4,350	5 00														51,370		17.241
		3,100	45	Broke											.251 x .252	74.70		49,010	

TABLE 3.—*TENSILE TESTS of square gun-wires of various manufacture*—Continued.

Mark of specimen designating—		Strain.		Elongation under strain.			Elongation after release.			Resilience.			Dimensions of cross-section.				Strain per square inch.		Elastic limit of strain compared with highest strain.
No. of experiment.	Material.	On specimen.	Time of application.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original area.	Original.	Under strain, (smallest place.)	Released, (smallest place.	Percentage of original area.	Of original area.	Of reduced area.	
		Lbs.	*m. s.*										*In.*		*In.*		*Lbs.*	*Lbs.*	*Per ct.*
81	N co I	750											.2895 x .2925				8,857		
		4,250	4 00														50,189		17.647
		3,000	2 30	Broke											.160 x .160	30.23		117,180	
82	P B co 1	1,350											.293 x .294				15,671		
		4,560	3 45														52,934		29.605
		3,010	1 00	Broke											.146 x .147	70.54		139,597	
83	P B co 1	1,350											.293 x .294				15,671		
		4,410	4 00														51,193		30.612
		2,750	1 30	Broke											.143 x .135	66.29		142,450	
84	P B co 2	1,400											.301 x .3035				15,325		
		6,630	3 15														72,585		21.116
		6,050	1 00	Broke											.235 x .235	60.45		10,955	
85	P B co 2	1,500											.301 x .3035				16,419		
		6,620	3 15														72,476		22.659
		6,150	30	Broke											.236 x .236	60.97		110,420	
86	P B co 3	1,550											.299 x .300				17,279		
		6,350	3 00														70,791		24.409
		5,700	1 00	Broke											.236 x .236	62.09		10,234	
87	P B co 3	1,600											.299 x .300				17,837		
		6,580	4 00														73,355		24.316
		6,000	1 30	Broke											.236 x .236	62.09		107,790	

TABLE 4.—*TENSILE TESTS of square gun-wires of various manufacture.*

[For explanation of marks, see pages 136 to 140, inclusive. Annealed at a heat between the melting-points of bronze and copper, without oxidation of surface.]

Mark on specimen designating—		Strain.		Elongation under strain.			Elongation after release.			Resilience.			Dimensions of cross section.				Strain per square inch.		Elastic limit of strain compared with highest strain.
Number of experiment.	Material.	On specimen.	Time of application.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	Original.	Under strain, (smallest place.)	Released, (smallest place.)	Percentage of original area.	Of original area.	Of reduced area.	
		Lbs.	m. s.	In.	In.		In.	In.		In.	In.		In.		In.		Lbs.	Lbs.	Per ct.
89	D	1,500	1 30		.000			.000					.302 x .303						
		2,000	3 45		.003	.06		.000			.003	.06							
		2,400	5 00		.005	.1		.000			.005	.1							
		2,600	3 00		.006	.12		.000			.006	.12							
		2,800	8 00		.007	.14		.000			.007	.14							
		3,000	8 00		.007	.14		.000			.007	.14							
		3,200	9 00		.008	.16		.000			.008	.16					34,972		
		3,400	16 45		.099	1.98		.091	1.82		.008	.16					37,158		
		5,800	7 30														63,387		55.172
		4,650	45	Broke											.202 x .203	44.81		113,398	
90	O	1,500	2 36		.002	.04		.000			.002	.04	.302 x .302						
		1,700	4 20		.003	.06		.000			.003	.06							
		1,900	3 58		.005	.1		.000			.005	.1							
		2,100	5 13		.005	.1		.000			.005	.1					23,025		
		2,300	24 18		.007	.14		.002	.04		.005	.10					25,218		
		5,150															56,455		44.660
		4,659		Broke											.200 x .208	45.61		111,995	
91	N co 1 S (A)	2,700	6 37	.020		.2	.003		.03	.017		.17	.3085 x .3042				28,773		
		7,500															79,925		36.000
		6,885	36 00	Broke				.688	13.76						.249 x .2524	66.97		109,551	
92	N co 1 S (B)	2,400	7 45	.008		.08	.002		.02	.006		.06	.3085 x .3042				25,573		
		7,030															74,910		34.139
		6,650	33 16	Broke			1.442		14.42						.2378 x .2517	63.77		111,103	

TABLE 4.—*TENSILE TESTS of square gun-wires of various manufacture*—Continued.

Mark on specimen designating—		Strain.		Elongation under strain.			Elongation after release.			Resilience.			Dimensions of cross-section.				Strain per square inch.		Elastic limit of strain compared with highest strain.
Number of experiment.	Material.	On specimen.	Time of application.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	Original.	Under strain, (smallest place.)	Released, (smallest place.)	Percentage of original area.	Of original area.	Of reduced area.	
		Lbs.	*m. s.*	*In.*	*In.*		*In.*	*In.*		*In.*	*In.*		*In.*		*In.*		*Lbs.*	*Lbs.*	*Per ct.*
93	N co 1 S (C)...	2,700	......	.011	......	.11	.002	......	.02	.019	.....	.09	.3035 x .3032	....	....	....	29,341	....	....
		7,550	......	.....	.....	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	82,046	....	35.762
		7,100	38 00	Broke	......	......	1.338	......	13.38	.....	.....	.....	....	....	.2462 x .2519	67.40	....	112,666	....
94	N co 1 S (D) ...	2,400	5 46	.085	......	.85	.003	......	.03	.082	.....	.82	.3035 x .302	....	....	....	26,181	....	....
		6,940	24 36	Broke	......	.....	1.802	......	18.02	.....	.....	.....	....	....	.2038 x .2039	45.34	75,717	....	34.582
95	N co 1 S (E)...	2,400	6 30	.012	......	.12	.004	......	.04	.008	.....	.08	.3032 x .305	....	....	....	25,952	....	....
		7,000	......	.....	.....	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	75,695	....	34.286
		6,630	25 02	Broke	......	.....	1.489	......	14.89	.....	.....	.....	....	....	.2488 x .2398	64.52	....	111.125	....
96	N co 1 S (F)....	2,400	5 27	.011	......	.11	.003	......	.3	.008	.....	.08	.3004 x .3052	....	....	....	26,177	....	....
		7,280	......	.....	.....	.....	.....	.....	.....	.....	.....	.....	....	....	....	....	79,404	....	32.967
		6,840	21 25	Broke	....	.....	1.333	......	15.33	.....	.....	.....	....	....	.245 x .252	67.34	....	110,787	....

TABLE 5.—*TENSILE TESTS of square gun-wires of various manufacture.*

[Annealed at a heat between the melting-points of bronze and copper, without oxidation. For explanation of marks, see pages 136 to 140 inclusive.]

Mark on specimen designating—		Strain.		Elongation under strain.			Elongation after release.			Resilience.			Dimensions of cross-section.				Strain per square inch.		Elastic limit of strain compared with highest strain.
No. of experiment.	Material.	On specimen.	Time of application.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	Original.	Under strain, (smallest place.)	Released, (smallest place.)	Percentage of original area.	Of original area.	Of reduced area.	
		Lbs	*m. s.*	*In.*	*In.*		*In.*	*In.*		*In.*	*In.*		*In.*	*In.*	*In.*		*Lbs.*	*Lbs.*	*Per ct.*
111	H W co 5	1,500	3 41	.003		.03	.000			.003		.03	.2987 x .2996						
		1.700	3 19	.003		.03	.000			.003		.03							
		2,000	5 30	.007		.07	.000			.007		.07							
		2,100	7 50	.008		.08	.000			.008		.08							
		2,400	18 07	.008		.08	.000			.008		.08					26,818		
		2,600	10 20	.009		.09	.001		.01	.008		.08					29,055		
		4,620	27 05														51,625		56.27
		3,250		Broke				1.042	20.84						.173 x .173	33.44		108,590	
112	H W co 6	1,500	5 16	.002		.02	.000			.002		.02	.2990 x .2996						
		1,700	4 45	.003		.03	.000			.003		.03							
		2,000	8 35	.004		.04	.000			.004		.04							
		2,100	4 15	.006		.06	.000			.006		.06					23,442		
		2,300	5 50	.007		.07	.002		.02	.005		.05					25,675		
		4,860	19 32														54,252		47.32
		3,500		Broke				.882	17.64						.183 x .188	38.41		104,777	
113	H W co 7	1,500	4 02	.004		.04	.000			.004		.04	.317 x .2994						
		1,700	4 14	.005		.05	.000			.005		.05							
		1,900	4 21	.006		.06	.000			.006		.06							
		2,100	4 20	.006		.06	.000			.006		.06							
		2,600	5 25	.007		.07	.000			.007		.07					27,394		
		2,700	4 39	.008		.08	.002		.02	.006		.06					28,448		
		6,100	19 38														64,271		44.93
		5,400		Broke				.704	14.08						.2278 x .2295	55.08		103,289	

TABLE 5.—*TENSILE TESTS of square gun-wires of various manufacture*—Continued.

Mark on specimen designating—		Strain.		Elongation under strain.			Elongation after release.			Resilience.			Dimensions of cross-section.				Strain per square inch.		Elastic limit of strain compared with highest strain.
No. of experiment.	Material.	On specimen.	Time of application.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	Original.	Under strain, (smallest place.)	Released, (smallest place.)	Percentage of original area.	Of original area.	Of reduced area.	
		Lbs.	*m. s.*	*In.*	*In.*		*In.*	*In.*		*In.*	*In.*		*In.*	*In.*	*In.*		*Lbs.*	*Lbs.*	*Per ct.*
114	J	1,500			.004	.08		.000			.004	.08	.3027 x .3027						
		1,700			.004	.08		.000			.004	.08							
		1,900			.005	.1		.000			.005	.1							
		2,100			.007	.14		.000			.007	.14							
		2,300			.007	.14		.000			.007	.14					25,101		
		2,500			.008	.16		.003	.06		.008	.16					27,284		
		6,075	20 47														66,301		41.15
		4,910			Broke										.204 x .2074	46.18		116,049	
115	U	1,500			.003	.06		.000			.003	.06	.3034 x .3043						
		1,700			.003	.06		.000			.003	.06							
		1,900			.004	.08		.000			.004	.08							
		2,100			.004	.08		.000			.004	.08							
		2,300			.006	.12		.000			.006	.12					24,901		
		2,500			.007	.14		.002	.04		.005	.10					26,970		
		5,850	24 00														63,363		42.73
		4,575			Broke										.199 x .200	43.11		114,949	
116	L	1,500			.004	.08		.000			.004	.08	.3013 x .3026						
		1,700			.004	.08		.000			.004	.08							
		1,900			.005	.1		.000			.005	.10					20,830		
		2,100			.007	.14		.002	.04		.005	.10					23,032		
		6,100	19 22		Broke			1.115	22.30					.273 x .272		81.45	66,905	82,148	34.42
		4,900													.2038 x .203	45.38		118,439	
117	I	1,500			.003	.06		.000			.003	.06	.3033 x .3031						
		1,700			.003	.06		.000			.003	.06							
		1,900			.004	.08		.000			.004	.08							
		2,100			.005	.1		.000			.004	.1							

		2,300			.005	.1		.000			.005	.1					25,018		
		2,500			.006	.12		.002	.04		.004	.08					27,194		
		5,730	16 17					.979	19.58					.270 x .270			62,231	78,449	43.70
		4,530			Broke										.1988 x .1988	42.99		114,641	
118	X	1,500			.003	.06		.000			.003	.06	.302 x .303						
		1,700			.004	.08		.000			.004	.08							
		1,900			.005	.1		.000			.005	.1							
		2,100			.005	.1		.000			.005	.1					22,949		
		2,300			.008	.16		.004	.08		.004	.08					25,134		
		5,880	15 20					.668	13.36					.267 x .267			64,258	82,230	39.11
		4,750			Broke										.209 x .209	47.73		108,742	
119	T	1,500			.003	.06		.000			.003	.06	.3028 x .3028						
		1,700			.003	.06		.000			.003	.06							
		1,900			.003	.06		.000			.003	.06							
		2,100			.005	.10		.000			.005	.10							
		2,300			.005	.10		.000			.005	.10							
		2,500			.005	.10		.000			.005	.10					27,157		
		2,700			.007	.14		.003	.06		.004	.08					29,331		
		6,190	10 02					.372	7.44					.275 x .275			67,245	80,528	43.61
		5,000			Broke										.258 x .283			68,480	
120	A G	1,500			.002	.04		.000			.002	.04	.302 x .301						
		1,700			.005	.10		.000			.005	.10							
		1,900			.005	.10		.000			.005	.10					20,901		
		2,100			.007	.14		.002	.04		.005	.10					23,101		
		5,690	11 20					.476	9.52					.266 x .269			62,594	79,520	36.90
		4,500			Broke										.2086 x .2053	45.76		108,189	
121	A N	1,500			.002	.04		.000			.002	.04	.304 x .3045						
		1,700			.003	.06		.000			.003	.06							
		1,900			.004	.08		.000			.004	.08					20,525		
		2,100			.005	.10		.003	.06		.002	.04					22,686		
		6,630	16 46					1.1021	22.04					.264 x .266			65,141	85,866	34.82
		4,800			Broke										.2078 x .2065	46.36		111,862	
122	A M	1,500			.002	.04		.000			.002	.04	.2988 x .2996						
		1,700			.004	.08		.000			.004	.08					19,497		
		1,900			.008	.16		.004	.08		.004	.08					21,791		
		5,925	14 21					1.087	21.74					.264 x .265		80.24	67,954	84,688	32.06
		5,000			Broke										.2136 x .2145	52.55		109,129	
123	A J	1,500			.003	.06		.000			.003	.06	.3033 x .3056						
		1,700			.003	.06		.000			.003	.06							
		1,900			.004	.08		.000			.004	.08							
		2,100			.004	.08		.000			.004	.08							
		2,300			.005	.10		.000			.005	.10					24,814		
		2,500			.007	.14		.002	.04		.005	.10					26,971		

TABLE 5.—*TENSILE TESTS of square gun-wires of various manufacture*—Continued.

Mark on specimen designating—		Strain.		Elongation under strain.			Elongation after release.			Resilience.			Dimensions of cross-section.				Strain per square inch.		Elastic limit of strain compared with highest strain.
No. of experiment.	Material.	On specimen.	Time of application.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	Original.	Under strain, (smallest place.)	Released, (smallest place.)	Percentage of original area.	Of original area.	Of reduced area.	
		Lbs.	*m. s.*	*In.*	*In.*		*In.*	*In.*		*In.*	*In.*		*In.*	*In.*	*In.*		*Lbs.*	*Lbs.*	*Per ct.*
		5, 550	14 45					1. 074	21. 48					. 269 x . 269		78. 07	59, 875	76, 666	45. 04
		4, 330			Broke										. 1963 x . 201	42. 58		109, 741	
124	A E	1, 500			. 004	. 08		. 000			. 004	. 08	. 303 x . 3047				16, 247		
		1, 700			. 006	. 12		. 002	. 04		. 004	. 08					18, 413		
		5, 470	13 06					1. 074	21. 48					. 270 x . 269			59, 247		31. 07
		4, 160			Broke										. 200 x . 200	43. 33		104, 000	
125	A P	1, 500			. 003	. 06		. 000			. 003	. 06	. 302 x . 3023						
		1, 700			. 003	. 06		. 000			. 003	. 06							
		1, 900			. 004	. 08		. 000			. 004	. 08							
		2, 100			. 004	. 08		. 000			. 004	. 08							
		2, 300			. 004	. 08		. 000			. 004	. 08							
		2, 500			. 005	. 1		. 000			. 005	. 1							
		2, 700			. 005	. 1		. 000			. 005	. 1					29, 574		
		2, 900			. 007	. 14		. 002	. 04		. 005	. 10					31, 765		
		5, 730	13 20					1. 158	23. 16					. 266 x . 270			62, 697	79, 782	50. 61
		4, 740			Broke										. 2075 x . 2109	47. 93		108, 313	
126	B A	1, 500			. 002	. 04		. 000			. 002	. 04	. 3063 x . 3031						
		1, 700			. 003	. 06		. 000			. 003	. 06							
		1, 900			. 004	. 08		. 000			. 004	. 08							
		2, 100			. 005	. 01		. 000			. 005	. 01							
		2, 300			. 005	. 01		. 000			. 005	. 01							
		2, 500			. 006	. 12		. 000			. 006	. 12							
		2, 700			. 006	. 12		. 000			. 006	. 12					29, 082		
		2, 900			. 007	. 14		. 001	. 02		. 006	. 12					31, 236		
		8, 480	22 14					. 685	13. 70					. 280 x . 284			93, 494	109, 154	33. 41
		8, 500			Broke										. 2605 x . 271	78. 07		116, 383	

127	B B	2,000			.004	.08		.000			.004	.08	.3062 x .3032						
		2,200			.004	.08		.000			.004	.08							
		2,400			.004	.08		.000			.004	.08							
		2,600			.005	.1		.000			.005	.1							
		2,800			.006	.12		.000			.006	.12					30,159		
		3,000			.007	.14		.002	.04		.005	.10					32,313		
		8,300	26 15					.734	14.68					.280 x .286		86.26	89,401	103,646	36.14
		8,000			Broke										.260 x .268	75.05		114,810	
128	B D	2,000			.002	.04		.000			.002	.04	.3030 x .3010						
		2,200			.005	.1		.000			.005	.1							
		2,400			.006	.12		.000			.006	.12					26,308		
		2,600			.007	.14		.003	.06		.004	.08					28,507		
		10,250	8 39					.517	10.34					.285 x .285		89.06	112,387	126,192	25.36
		9,890			Broke										.283 x .2793	86.67		124,996	
129	B E	2,000			.000			.000					.304 x .304						
		2,200			.000			.000											
		2,400			.000			.000											
		2,600			.000			.000											
		2,800			.000			.000											
		3,000			.000			.000											
		3,200			.004	.08		.000			.004	.08							
		3,400			.004	.08		.000			.004	.08							
		3,600			.006	.12		.000			.006	.12							
		3,800			.006	.12		.000			.006	.12							
		4,000			.007	.14		.003	.06		.004	.08							
		9,950	14 37					.457	9.14					.290 x .296			106,600	115,913	40.20
		9,675			Broke														
130	B F	2,000			.000			.000					.3028 x .3025						
		2,250			.000			.000											
		2,400			.000			.000											
		2,600			.000			.000											
		2,800			.000			.000											
		3,000			.000			.000									32,763		
		3,200			.040	.8		.040	.8		.000	.09					34,935		
		7,500	14 20					.431	8.61					.286 x .290			81,880	90,426	41.33
		6,100			Broke			.976	19.52						.2345 x .2355	60.29		110,457	
131	B G	2,000			.000			.000					.3028 x .3029						
		2,200			.000			.000											
		2,400			.000			.000											
		2,600			.002	.04		.000			.002	.04							
		2,800			.002	.04		.000			.002	.04							
		3,000			.003	.06		.000			.003	.06							
		3,200			.004	.08		.000			.004	.08					34,889		
		3,400			.008	.16		.002	.04		.006	.12					37,070		
		7,985	14 17					.804	16.04					.280 x .280		85.48	87,060	101,858	42.58
		7,450			Broke			.874	17.48						.254 x .254	70.34		115,475	

TABLE 5.—*TENSILE TESTS of square gun-wires of various manufacture*—Continued.

Mark on specimen designating—		Strain.		Elongation under strain.			Elongation after release.			Resilience.			Dimensions of cross-section.				Strain per square inch.		Elastic limit of strain compared with highest strain.
No. of experiment.	Material.	On specimen.	Time of application.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	Original.	Under strain. (smallest place.)	Released, (smallest place.)	Percentage of original area.	Of original area.	Of reduced area.	
		Lbs.	*m. s.*	*In.*	*In.*		*In.*	*In.*		*In.*	*In.*		*In.*	*In.*	*In.*		*Lbs.*	*Lbs.*	*Per ct.*
132	B H	2, 000			.003	.06		.000			.003	.06	.3058 x .3090						
		2, 200			.003	.06		.000			.003	.06							
		2, 400			.004	.08		.000			.004	08							
		2, 600			.005	.1		.000			.005	1							
		2, 800			.005	.1		.000			.005	1							
		3, 000			.006	.12		.000			.006	12							
		3, 200			.006	.12		.000			.006	.12					33, 868		
		3, 400			.007	.14		.004	.08		.003	.06					35, 985		
		8, 670	9 00					.762	15. 24					.281 x .288		85. 65	91, 703	107, 132	39. 21
		8, 275			Broke										.1903 x .1950				
133	B I	2, 000			.003	.06		.000			.003	.06	.3048 x .3035						
		2, 200			.003	.06		.000			.003	.06							
		2, 400			.004	.08		.000			.004	.08							
		2, 000			.005	.1		.000			.005	.1					28, 106		
		2, 800			.006	.12		.003	.06		.003	.06					30, 268		
		7, 880						.694	13. 88					.284 x .285		87. 50	85, 182	97, 356	35. 53
		7, 400			Broke										.2538 x .2573	70. 48		113, 318	
134	B K	2, 000			.003	.06		.000			.003	.06	.3010 x .3023						
		2, 200			.003	.06		.000			.003	.06							
		2, 400			.004	.08		.000			.004	.08							
		2, 600			.005	.10		.000			.005	.10							
		2, 800			.006	.12		.000			.006	.12							
		3, 000			.006	.12		.000			.006	.12					32, 969		
		3, 200			.007	.14		.003	.06		.007	.14					35, 167		
		8, 650	6 08					.605	12. 10					.283 x .280		87. 08	95, 062	107, 900	36. 99
		8, 425			Broke										.2715 x .2693	80. 35		115, 229	

135	B M	2,000			.001	.02		.000			.001	.02	.3038 x .3043						
		2,200			.002	.04		.000			.002	.04							
		2,400			.003	.06		.000			.003	.06							
		2,600			.004	.08		.000			.004	.08							
		2,800			.004	.08		.000			.004	.08							
		3,000			.005	.1		.000			.005	.1					32,472		
		3,900			.006	.12		.002	.02		.006	.12					34,637		
		10,180	6 41					.534	5.34					.285 x .286		88.23	110,190	124,892	31.43
		9,780			Broke										.2823 x .2814	81.13		132,340	
137	C Hco 4S	1,500		.004		.04	.000			.004		.04	.2920 x .2950						
		1,700		.005		.05	.000			.005		.05							
		1,900		.005		.05	.000			.005		.05							
		2,100		.007		.07	.000			.007		.07					24,378		
		2,300		.008		.08	.002		.02	.006		.06					26,700		
		8,150	15 21				1.328	.571	13.28					.268 x .265		82.45	94,616	114,756	28.22
		7,700		Broke											.2472 x .2472	70.94		126,008	
138	C F	1,500		.002		.02	.000			.002		.02	.2960 x .2970						
		1,700		.003		.03	.000			.003		.03							
		1,900		.004		.04	.000			.004		.04							
		2,100		.004		.04	.000			.004		.04							
		2,300		.006		.06	.000			.006		.06							
		2,500		.008		.08	.000			.008		.08							
		2,700		.009		.09	.000			.009		.09							
		2,900		.010		.1	.000			.010		.1							
		3,100		.010		.1	.000			.010		.1							
		3,300		.010		.1	.000			.010		.1							
		3,500		.011		.11	.000			.011		.11							
		3,700		.011		.11	.000			.011		.11							
		3,900		.012		.12	.000			.012		.12							
		4,100		.012		.12	.000			.012		.12					46,638		
		4,300		.162		1.62	.143	.716	1.43	.019		.19					48,912		
		7,190	8 38				1.657		16.57					.266 x .267		80.79	81,787	101,236	58.41
		6,800		Broke											.2458 x .2445	68.36		113,148	
139	C G	3,000		.012		.12	.000			.012		.12	.2958 x .2973						
		3,200		.013		.13	.000			.013		.13					36,387		
		3,400		.014		.14	.001		.01	.013		.13					38,662		
		3,600		.016		.16	.104		1.04	.012		.12							
		6,325	28 26				1.568	1.187	15.68					.275 x .275		86.00	71,922	83,636	53.75
		5,800		Broke											.225 x .2288	58.54		112,665	
140	C H	3,000		.011		.11	.000			.011		.11	.2959 x .2968						
		3,200		.012		.12	.000			.012		.12							
		3,400		.014		.14	.000			.014		.14							
		3,600		.014		.14	.000			.014		.14					40,991		
		3,800		.140		1.4	.125		1.25	.015		.15					43,189		

TABLE 5.—*TENSILE TESTS of square gun-wires of various manufacture*—Continued.

Mark on specimen designating—		Strain.		Elongation under strain.			Elongation after release.			Resilience.			Dimensions of cross-section.				Strain per square inch.		Elastic limit of strain compared with highest strain.
No. of experiment.	Material.	On specimen.	Time of application.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	Original.	Under strain, (smallest place.)	Released, (smallest place.)	Percentage of original area.	Of original area.	Of reduced area.	
		Lbs.	*m. s.*	*In.*	*In.*		*In.*	*In.*		*In.*	*In.*		*In.*	*In.*	*In.*		*Lbs.*	*Lbs.*	*Per ct.*
		7,000	11 32				1.881	.825	18.81					.263 x .263		78.75	79,705	101,201	52.85
		6,300		Broke											.2275 x .2275	58.93		121,724	
141	C I	3,000		.009		.09	.000			.009		.09	.297 x .298						
		3,200		.010		.1	.000			.010		.1							
		3,400		.010		.1	.000			.010		.1							
		3,600		.012		.12	.000			.012		.12					40,675		
		3,700		.139		1.39	.124		1.24	.015		.15					41,805		
		6,760	12 10				1.824	.788	18.24					.266 x .267		80.25	76,377	95,181	53.69
		6,070		Broke											.2236 x .2255	56.97		120,384	
142	C J	3,000		.011		.11	.000			.011		.11	.2982 x .2987						
		3,200		.011		.11	.000			.011		.11							
		3,400		.012		.12	.000			.012		.12							
		3,600		.012		.12	.000			.012		.12					40,420		
		3,800		.019		.19	.009		.09	.010		.10					42,665		
		7,310	11 30				1.824	.799	18.24					.266 x .266		79.44	82,076	103,312	50.61
		6,460		Broke											.2190 x .2176	53.51		135,559	
143	C K	3,000		.009		.09	.000			.009		.09	.2990 x .2975						
		3,200		.009		.09	.000			.009		.09							
		3,400		.010		.1	.000			.010		.1							
		3,600		.010		.1	.000			.010		.1							
		3,800		.010		.1	.000			.010		.1							
		4,000		.010		.1	.000			.010		.1							
		4,200		.010		.1	.000			.010		.1							
		4,400		.012		.12	.000			.012		.12					49,464		
		4,600		.108		1.08	.091		.91	.017		.17					51,714		
		8,600	10 35				1.420	.566	14.2					.268 x .268		80.74	96,680	119,737	51.74

		8,025		Broke											.2490 x .2403	65.37		138,000	
144	C F	3,000		.005		.05	.000			.005		.05	.2970 x .2964						
		3,200		.005		.05	.000			.005		.05							
		3,400		.011		.11	.000			.011		.11							
		3,600		.011		.11	.000			.011		.11							
		3,800		.015		.15	.000			.015		.15					43,166		
		4,000		.079		.79	.063		.63	.016		.16					45,438		
		7,075	11 15				2.017	.955	20.17					.268 x .265		80.68	80,369	99,619	53.85
		6,550		Broke											.2390 x .2410	65.43		113,717	
145	C G	3,000		.009		.09	.000			.009		.09	.2965 x .2970						
		3,200		.011		.11	.000			.011		.11					36,338		
		3,400		.025		.25	.014		.14	.011		.11					38,609		
		6,450	20 05				1.503	.970	15.03					.277 x .275		86.50	73,244	84,674	50.07
		5,690		Broke											.2205 x .2238	55.92		115,538	
146	C H	3,000		.012		.12	.000			.012		.12	.2967 x .2978						
		3,200		.013		.13	.000			.013		.13					36,216		
		3,300		.015		.15	.003		.03	.012		.12					37,348		
		3,500		.016		.16	.004		.04	.012		.12							
		3,700		.026		.26	.012		.12	.014		.14							
		7,100	19 14				1.668	.781	16.68					.273 x .274		84.65	80,355	94,917	49.29
		6,350		Broke											.2255 x .2246	67.51		125,376	
147	C I	3,000		.009		.09	.000			.009		.09	.2970 x .2968						
		3,200		.010		.1	.000			.010		.1							
		3,400		.011		.11	.000			.011		.11							
		3,600		.012		.12	.000			.012		.12					40,839		
		3,800		.024		.24	.011		.11	.013		.13					43,108		
		6,960	9 16				1.665	.721	16.65					.255 x .255		73.77	78,956	107,035	53.16
		6,380		Broke											.2445 x .2433	67.48		107,250	
148	C J	3,000		.010		.1	.000			.010		.1	.2985 x .2970						
		3,200		.013		.13	.000			.013		.13							
		3,400		.015		.15	.000			.015		.15							
		3,500		.015		.15	.000			.015		.15							
		3,600		.015		.15	.000			.015		.15					40,607		
		3,800		.045		.45	.030		.3	.015		.15					42,863		
		7,150	13 26				2.200	.994	22.0					.272 x .270		82.84	80,650	97,358	51.74
		6,200		Broke											.2406 x .2414	65.51		106,747	
149	C K	3,000		.009		.09	.000			.009		.09	.2967 x .2988						
		3,200		.011		.11	.000			.011		.11							
		3,400		.012		.12	.000			.012		.12							
		3,600		.014		.14	.000			.014		.14							
		3,700		.014		.14	.000			.014		.14							
		3,800		.015		.15	.000			.015		.15							
		4,000		.016		.16	.000			.016		.16							

TABLE 5.—*TENSILE TESTS of square gun-wires of various manufacture*—Continued.

Mark on specimen designating—		Strain.		Elongation under strain.			Elongation after release.			Resilience.			Dimensions of cross-section.				Strain per square inch.		Elastic limit of strain compared with highest strain.
No. of experiment.	Material.	On specimen.	Time of application.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	Original.	Under strain, (smallest place.)	Released, (smallest place.)	Percentage of original area.	Of original area.	Of reduced area.	
		Lbs.	*m. s.*	*In.*	*In.*		*In.*	*In.*		*In.*	*In.*		*In.*	*In.*	*In.*		*Lbs.*	*Lbs.*	*Per ct.*
		4,200		.017		.17	.000			.017		.17					47,375		
		4,400		.087		.87	.070	.418	.7	.017		.17					49,631		
		8,100	8 35				1.235		12.35					.263 x .260		77.13	91,366	118,455	52.58
		7,585		Broke											.2396 x .2403	64.94		131,739	
154	H W co 9	2,000	2 29	.003		.03	.000			.003		.03	.2979 x .2988						
		2,200	2 35	.003		.03	.000			.003		.03							
		2,400	3 07	.007		.07	.000			.007		.07							
		2,600	3 33	.009		.09	.000			.009		.09							
		2,800	2 52	.010		.1	.000			.010		.1							
		3,000	5 05	.008		.08	.000			.008		.08							
		3,200	3 30	.009		.09	.000			.009		.09							
		3,400	3 03	.010		.1	.000			.010		.1							
		3,600	4 29	.011		.11	.000			.011		.11							
		3,800	11 45	.058		.58	.000			.058		.58							
		6,000	6 40	.230		2.3	.000			.230		2.3							
		8,400	5 17																
		8,525	2 05														95,773		43.40
		8,340	10	Broke											.260 x .260	75.94		123,370	
155	H W co 9 = ..	2,000	2 40				.009	.000	.09				.302 x .301						
		2,200	2 42				.009	.000	.09										
		2,400	3 30				.009	.000	.09										
		2,600	2 34				.009	.000	.09										
		2,800	2 52				.011	.000	.110										
		3,000	2 29				.013	.000	.130										
		3,200	2 54				.013	.000	.130								35,202		
		3,400	3 16				.015	.002	.150								37,402		
		3,600	4 08				.017	.002	.17										

		3,800	3 43				.019	.005	.19										
		6,000	7 17				.230	.196	2.3										
		8,400	3 12																
		8,600	4 30														94,607		43.02
		8,250	24	Broke				.771	15.42						.2525 x .2535	70.41		127,326	
156	T co 3 *.....	2,000	2 32	.006		.06	.000			.006		.06	.300 x .3005						
		2,200	3 36	.009		.09	.000			.009		.09							
		2,400	2 46	.009		.09	.000			.009		.09					26,622		
		2,600	4 19	.010		.1	.002		.02	.008		.08					28,840		
		2,800	3 56	.010		.1	.002		.02	.008		.08							
		3,000	3 34	.012		.12	.004		.04	.008		.08							
		3,200	4 07	.014		.14	.004		.04	.010		.10							
		3,400	4 33	.020		.2	.010		.1	.010		.1							
		6,000	8 00	.242		2.42	.207		2.07	.035		.035							
		8,340	7 35																
		8,500	2 30														94,287		40.00
		8,330	12	Broke				.608	12.16						.299 x .2985			93,331	
157	T co 3 * — ...	2,000	3 15	.001		.01	.000			.001		.01	.2985 x .301						
		2,200	3 34	.005		.05	.000			.005		.05							
		2,400	2 54	.008		.08	.000			.008		.08							
		2,600	3 11	.008		.08	.000			.008		.08							
		2,800	2 38	.009		.09	.000			.009		.09							
		3,000	3 15	.009		.09	.000			.009		.09							
		3,200	3 46	.010		.1	.000			.010		.1							
		3,400	6 30	.012		.12	.000			.012		.12					37,841		
		3,600	7 08	.054		.54	.036		.36	.018		.18					40,067		
		6,000	13 00	.251		2.51	.245		2.45	.006		.06							
		8,280	2 47																
		8,380	1 30														93,269		41.76
		8,360	07	Broke				.503	10.06						.2708 x .2723	82.07		113,373	
158	A co 2	2,000	2 19	.007		.07	.000			.007		.07	.2988 x .2978						
		2,200	1 56	.008		.08	.000			.008		.08							
		2,400	1 54	.009		.09	.000			.009		.09							
		2,600	1 36	.010		.100	.000			.010		.1							
		2,800	1 40	.010		.100	.000			.010		.1							
		3,000	2 41	.012		.120	.000			.012		.12							
		3,200	3 37	.012		.120	.000			.012		.12							
		3,400	4 42	.012		.120	.000			.012		.12							
		3,600	3 44	.014		.140	.000			.014		.14							
		3,800	4 44	.015		.150	.005		.05	.010		.100							
		4,000	3 02	.018		.180	.005		.05	.013		.130							
		4,200	3 05	.019		.190	.005		.05	.014		.140							
		4,400	20 05	.064		.640	.048		.48	.016		.160							
		6,000	8 12	.321		3.210	.293		2.930	.028		.280							

* About.

TABLE 5.—*TENSILE TESTS of square gun-wires of various manufacture*—Continued.

Mark on specimen designating—		Strain.		Elongation under strain.			Elongation after release.			Resilience.			Dimensions of cross-section.				Strain per square inch.		Elastic limit of strain compared with highest strain.
No. of experiment.	Material.	On specimen.	Time of application.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	Original.	Under strain, (smallest place.)	Released, (smallest place.)	Percentage of original area.	Of original area.	Of reduced area.	
		Lbs.	*m. s.*	*In.*	*In.*		*In.*	*In.*		*In.*	*In.*		*In.*	*In.*	*In.*		*Lbs.*	*Lbs.*	*Per ct.*
		7,950	7 18														89,344		52.83
		7,330		Broke				.595	11.90						.2396 x .2463	64.70		127,320	
159	A co 5	2,000	3 02	.003		.03	.000			.003		.03	.2983 x .2988						
		2,200	2 15	.004		.04	.000			.004		.04							
		2,400	2 31	.005		.05	.000			.005		.05							
		2,600	4 35	.008		.08	.004		.04	.004		.04							
		2,800	2 07	.008		.08	.004		.04	.004		.04							
		3,000	2 16	.009		.09	.004		.04	.005		.05							
		3,200	2 05	.011		.11	.006		.06	.005		.05							
		3,400	2 16	.012		.12	.006		.06	.006		.06							
		3,600	3 28	.012		.12	.007		.07	.005		.05							
		3,800	5 38	.013		.13	.008		.08	.005		.05							
		6,000	11 50	.300		3.00	.274		2.740	.026		.26							
		8,000	3 39																
		8,190	2 00														91,886		43.96
		7,456	42	Broke				.608	12.16						.2425 x .242	65.53		126,778	
160	H W co 17	2,000	2 31	.005		.05	.000			.005		.05	.2987 x .298						
		2,200	2 37	.007		.07	.000			.007		.07							
		2,400	3 49	.007		.07	.000			.007		.07							
		2,600	5 59	.008		.08	.000			.008		.08							
		2,800	3 15	.009		.09	.000			.009		.09							
		3,000	8 00	.011		.11	.000			.011		.11							
		3,200	34 52	.090		.90	.078		.78	.190		.12							
		6,925	11 30														77,798		44.04
		6,375		Broke			1.337		13.370						.233 x .2375			115,170	

161	S P R 6	2,000	2 40	.006		.06	.000			.006		.06	.2987 x .2970						
		2,200	2 02	.008		.08	.000			.008		.08							
		2,400	1 56	.010		.1	.000			.010		.1							
		2,600	2 07	.010		.1	.000			.010		.1							
		2,800	2 14	.011		.11	.000			.011		.11							
		3,000	2 09	.012		.12	.003		.03	.009		.09							
		3,200	2 37	.013		.13	.003		.03	.010		.10							
		3,400	3 16	.013		.13	.003		.03	.010		.10							
		3,600	2 44	.014		.14	.003		.03	.011		.11							
		3,800	2 55	.016		.16	.004		.04	.012		.12							
		4,000	22 56	.084		.84	.065		.65	.019		.19							
		8,000	13 29														89,947		47.50
		7,350		Broke			1.672	.793	16.72						.239 x .242	64.91		127,060	
162	S P R 13	2,000	2 25	.005		.05	.000			.005		.05	.297 x .298						
		2,200	2 28	.010		.1	.000			.010		.1							
		2,400	2 22	.010		.1	.000			.010		.1							
		2,600	2 00	.010		.1	.000			.010		.1							
		2,800	3 45	.012		.12	.000			.012		.12							
		3,000	3 05	.013		.13	.004		.04	.009		.09							
		3,200	1 44	.013		.13	.004		.04	.009		.09							
		3,400	8 52	.124		1.24	.013		.13	.011		.11							
		6,625	14 33														74,853		48.30
		5,850		Broke			1.929	.812	19.29						.225 x .2268	57.64		114,638	
163	S P R 19	2,000	1 50	.005		.05	.000			.005		.05	.298 x .298						
		2,200	1 16	.006		.06	.000			.006		.06							
		2,400	1 39	.008		.08	.000			.008		.08							
		2,600	1 06	.008		.08	.000			.008		.08							
		2,800	1 35	.009		.09	.000			.009		.09							
		3,000	1 56	.013		.13	.003		.03	.010		.10							
		3,200	2 29	.014		.14	.005		.05	.009		.09							
		3,400	1 29	.015		.15	.005		.05	.010		.10							
		3,600	4 51	.016		.16	.006		.06	.010		.10							
		3,800	4 29	.016		.16	.006		.06	.010		.10							
		4,000	6 52	.031		.31	.015		.15	.016		.16							
		8,025	12 32														90,367		47.35
		7,350		Broke				.765	15.30						.2365 x .235	62.59		130,448	
164	S P R 22	2,600	3 19	.009		.09	.000			.009		.09	.299 x .298						
		2,800	2 25	.011		.11	.003		.03	.008		.08							
		3,000	1 45	.011		.11	.003		.03	.008		.08							
		3,200	2 19	.012		.12	.004		.04	.008		.08							
		3,400	3 23	.013		.13	.004		.04	.009		.09							
		3,600	1 51	.013		.13	.004		.04	.009		.09							
		3,800	3 09	.014		.14	.004		.04	.010		.10							
		4,000	10 00	.080		.8	.066		.66	.014		.14							
		7,860	10 32														88,213		48.35
		7,350		Broke				.641	12.82						.2335 x .231	60.60		136,266	

TABLE 5.—*TENSILE TESTS of square gun-wires of various manufacture*—Continued.

Mark on specimen designating—		Strain.		Elongation under strain.			Elongation after release.			Resilience.			Dimensions of cross-section.				Strain per square inch.		Elastic limit of strain compared with highest strain.
No. of experiment.	Material.	On specimen.	Time of application.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	Original.	Under-strain, (smallest place.)	Released, (smallest place.)	Percentage of original area.	Of original area.	Of reduced area.	
		Lbs.	*m. s.*	*In.*	*In.*		*In.*	*In*		*In.*	*In.*		*In.*	*In.*	*In.*		*Lbs.*	*Lbs.*	*Per ct.*
165	S P R 27	2, 600	3 18	.012	......	.12	.002	......	.02	.010	......	.10	.299 x .299	......	......	......	......	......	......
		2, 800	1 27	.013	......	.13	.004	......	.04	.009	......	.09	......	......	......	......	......	......	......
		3, 000	1 25	.014	......	.14	.005	......	.05	.009	......	.09	......	......	......	......	......	......	......
		3, 200	1 13	.014	......	.14	.005	......	.05	.009	......	.09	......	......	......	......	......	......	......
		3, 400	1 57	.014	......	.14	.005	......	.05	.009	......	.09	......	......	......	......	......	......	......
		3, 600	1 26	.015	......	.15	.006	......	.06	.009	......	.09	......	......	......	......	......	......	......
		3, 800	57	.018	......	.18	.007	......	.07	.011	......	.11	......	......	......	......	......	......	......
		4, 000	1 51	.020	......	.2	.010	......	.1	.010	......	.1	......	......	......	......	......	......	......
		8, 680	8 10	......	......	......	......	......	......	......	......	......	......	......	......	......	97, 091	......	43. 78
		8, 200	......	Broke	......	......	......	.464	9. 28	......	......	......	......	......	.244 x .243	65. 14	......	138, 300	......
170*	O—	1, 800	2 25	.004	......	.04	.000	......	......	.004	......	.04	.3014 x .3015	......	......	......	......	......	......
		2, 000	2 15	.008	......	.08	.000	......	......	.008	......	.08	......	......	......	......	......	......	......
		2, 200	2 30	.008	......	.08	.000	......	......	.008	......	.08	......	......	......	......	......	......	......
		2, 400	4 55	.010	......	.10	.000	......	......	.010	......	.10	......	......	......	......	......	......	......
		2, 600	3 25	.011	......	.11	.001	......	.01	.010	......	.10	......	......	......	......	......	......	......
		2, 800	4 05	.011	......	.11	.002	......	.02	.009	......	.09	......	......	......	......	......	......	......
		3, 000	5 00	.013	......	.13	.004	......	.04	.009	......	.09	......	......	......	......	......	......	......
		3, 200	5 00	.020	......	.20	.010	......	.10	.010	......	.10	......	......	......	......	......	......	......
		5, 400	9 25	......	......	......	......	......	......	......	......	......	......	......	......	......	59, 424	......	55. 70
		4, 475	18	Broke	......	......	1. 054	......	10. 54	......	......	......	......	......	.195 x .195	41. 84	......	117, 685	......
171*	=O	1, 800	2 05	.008	......	.08	.000	......	......	.008	......	.08	.3014 x .3014	......	......	......	......	......	......
		2, 000	2 25	.009	......	.09	.000	......	......	.009	......	.09	......	......	......	......	......	......	......
		2, 200	2 00	.009	......	.09	.000	......	......	.009	......	.09	......	......	......	......	......	......	......
		2, 400	3 10	.010	......	.10	.000	......	......	.010	......	.10	......	......	......	......	......	......	......
		2, 600	2 30	.010	......	.10	.001	......	.01	.009	......	.09	......	......	......	......	......	......	......
		2, 800	3 00	.010	......	.10	.001	......	.01	.009	......	.09	......	......	......	......	......	......	......
		3, 000	3 30	.012	......	.12	.001	......	.01	.011	......	.11	......	......	......	......	......	......	......

		3,200	7 00	.013		.13	.002		.02	.011		.11							
		3,400	14 10	.210		2.10	.196		1.96	.014		.14							
		5,360	7 20														59,004		59.70
		4,325	35	Broke				.905	18.10						.197 x .197	42.83		111,443	
172	H W co 16 *	2,400	2 18	.006		.06	.000			.006		.06	.299 x .2982						
		2,600	2 45	.008		.08	.000			.008		.08							
		2,800	17 00	.093		.93	.086		.86	.007		.07							
		6,000	7 15														67,293		45.00
		4,625	45	Broke				.813	16.26						.185 x .180	37.81		13,888	
173	M co 2 *	2,400	2 00	.010		.10	.000			.010		.10	.298 x .2986						
		2,600	2 00	.010		.10	.000			.010		.10							
		2,800	2 15	.011		.11	.000			.011		.11							
		3,000	2 45	.011		.11	.000			.011		.11							
		3,200	2 05	.012		.12	.000			.012		.12							
		3,400	2 35	.012		.12	.000			.012		.12							
		3,600	2 00	.013		.13	.000			.013		.13							
		3,800	11 40	.249		2.49	.228		2.28	.021		.21							
		5,850	5 50														65,817		63.24
		4,600	35	Broke				.967	19.34						.199 x .199	44.37		11,616	
174	M co 3 *	2,400	1 53	.007		.07	.000			.007		.07	.299 x .2988						
		2,600	1 30	.007		.07	.000			.007		.07							
		2,800	2 45	.009		.09	.000			.009		.09							
		3,000	1 45	.012		.12	.000			.012		.12							
		3,200	2 40	.012		.12	.000			.012		.12							
		3,400	2 00	.012		.12	.000			.012		.12							
		3,600	2 00	.013		.13	.000			.013		.13							
		3,800	2 00	.013		.13	.000			.013		.13							
		4,000	1 55	.013		.13	.000			.013		.13							
		4,200	2 15	.015		.15	.000			.015		.15							
		4,400	9 30	.020		.20	.006		.06	.014		.14							
		4,600	7 40	.139		1.39	.020		.20	.019		.19							
		8,410	9 35														94,123		51.83
		7,850	25	Broke				.494	9.88						.240 x .240	66.10		136,280	
175	A co 5	2,600	1 15	.010		.10	.000			.010		.10	.299 x .299						
		2,800	2 20	.012		.12	.000			.012		.12							
		3,000	1 30	.012		.12	.000			.012		.12							
		3,200	1 15	.013		.13	.000			.013		.13							
		3,400	1 15	.014		.14	.000			.014		.14							
		3,600	2 30	.016		.16	.000			.016		.16							
		3,800	2 40	.016		.16	.000			.016		.16							
		4,000	7 30	.016		.16	.000			.016		.16							
		4,200	8 40	.018		.18	.000			.018		.18							
		4,400	5 15	.018		.18	.000			.018		.18							

* Cut at the end of torsional specimen No. 848, and annealed with it.

TABLE 5.—*TENSILE TESTS of square gun-wires of various manufacture*—Continued.

Mark on specimen designating—		Strain.		Elongation under strain.			Elongation after release.			Resilience.			Dimensions of cross-section.				Strain per square inch.		
No. of experiment.	Material.	On specimen.	Time of application.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	Original.	Under-strain, (smallest place.)	Released, (smallest place.)	Percentage of original area.	Of original area.	Of reduced area.	Elastic limit of strain compared with highest strain.
		Lbs.	*m. s.*	*In.*	*In.*		*In.*	*In*		*In.*	*In.*		*In.*	*In.*	*In.*		*Lbs.*	*Lbs.*	*Per ct.*
165	S P R 27	2, 600	3 18	.012		.12	.002		.02	.010		.10	.299 x .299						
		2, 800	1 27	.013		.13	.004		.04	.009		.09							
		3, 000	1 25	.014		.14	.005		.05	.009		.09							
		3, 200	1 13	.014		.14	.005		.05	.009		.09							
		3, 400	1 57	.014		.14	.005		.05	.009		.09							
		3, 600	1 26	.015		.15	.006		.06	.009		.09							
		3, 800	57	.018		.18	.007		.07	.011		.11							
		4, 000	1 51	.020		.2	.010		.1	.010		.1							
		8, 680	8 10														97, 091		43. 78
		8, 200		Broke				.464	9. 28						.244 x .243	65. 14		138, 300	
170*	O—	1, 800	2 25	.004		.04	.000			.004		.04	.3014 x .3015						
		2, 000	2 15	.008		.08	.000			.008		.08							
		2, 200	2 30	.008		.08	.000			.008		.08							
		2, 400	4 55	.010		.10	.000			.010		.10							
		2, 600	3 25	.011		.11	.001		.01	.010		.10							
		2, 800	4 05	.011		.11	.002		.02	.009		.09							
		3, 000	5 00	.013		.13	.004		.04	.009		.09							
		3, 200	5 00	.020		.20	.010		.10	.010		.10							
		5, 400	9 25														59, 424		55. 70
		4, 475	18	Broke			1. 054		10. 54						.195 x .195	41. 84		117, 685	
171*	=O	1, 800	2 05	.008		.08	.000			.008		.08	.3014 x .3014						
		2, 000	2 25	.009		.09	.000			.009		.09							
		2, 200	2 00	.009		.09	.000			.009		.09							
		2, 400	3 10	.010		.10	.000			.010		.10							
		2, 600	2 30	.010		.10	.001		.01	.009		.09							
		2, 800	3 00	.010		.10	.001		.01	.009		.09							
		3, 000	3 30	.012		.12	.001		.01	.011		.11							

		3, 200	7 00	.013		.13	.002		.02	.011		.11							
		3, 400	14 10	.210		2.10	.196		1.96	.014		.14							
		5, 360	7 20														59, 004		59.70
		4, 325	35	Broke				.905	18.10						.197 x .197	42.83		111, 443	
172	*H W co 16* *	2, 400	2 18	.006		.06	.000			.006		.06	.299 x .2982						
		2, 600	2 45	.008		.08	.000			.008		.08							
		2, 800	17 00	.093		.93	.086		.86	.007		.07							
		6, 000	7 15														67, 293		45.00
		4, 625	45	Broke				.813	16.26						.185 x .180	37.81		13, 888	
173	M co 2 *	2, 400	2 00	.010		.10	.000			.010		.10	.298 x .2986						
		2, 600	2 00	.010		.10	.000			.010		.10							
		2, 800	2 15	.011		.11	.000			.011		.11							
		3, 000	2 45	.011		.11	.000			.011		.11							
		3, 200	2 05	.012		.12	.000			.012		.12							
		3, 400	2 35	.012		.12	.000			.012		.12							
		3, 600	2 00	.013		.13	.000			.013		.13							
		3, 800	11 40	.249		2.49	.228		2.28	.021		.21							
		5, 850	5 50														65, 817		63.24
		4, 600	35	Broke				.967	19.34						.199 x .199	44.37		11, 616	
174	M co 3 *	2, 400	1 53	.007		.07	.000			.007		.07	.299 x .2988						
		2, 600	1 30	.007		.07	.000			.007		.07							
		2, 800	2 45	.009		.09	.000			.009		.09							
		3, 000	1 45	.012		.12	.000			.012		.12							
		3, 200	2 40	.012		.12	.000			.012		.12							
		3, 400	2 00	.012		.12	.000			.012		.12							
		3, 600	2 00	.013		.13	.000			.013		.13							
		3, 800	2 00	.013		.13	.000			.013		.13							
		4, 000	1 55	.013		.13	.000			.013		.13							
		4, 200	2 15	.015		.15	.000			.015		.15							
		4, 400	9 30	.020		.20	.006		.06	.014		.14							
		4, 600	7 40	.139		1.39	.020		.20	.019		.19							
		8, 410	9 35														94, 123		51.83
		7, 850	25	Broke				.494	9.88						.240 x .240	66.10		136, 280	
175	A co 5	2, 600	1 15	.010		.10	.000			.010		.10	.299 x .299						
		2, 800	2 20	.012		.12	.000			.012		.12							
		3, 000	1 30	.012		.12	.000			.012		.12							
		3, 200	1 15	.013		.13	.000			.013		.13							
		3, 400	1 15	.014		.14	.000			.014		.14							
		3, 600	2 30	.016		.16	.000			.016		.16							
		3, 800	2 40	.016		.16	.000			.016		.16							
		4, 000	7 30	.016		.16	.000			.016		.16							
		4, 200	8 40	.018		.18	.000			.018		.18							
		4, 400	5 15	.018		.18	.000			.018		.18							

* Cut at the end of torsional specimen No. 848, and annealed with it.

TABLE 5.—*TENSILE TESTS of square gun-wires of various manufacture*—Continued.

Mark on specimen designating—		Strain.		Elongation under strain.			Elongation after release.			Resilience.			Dimensions of cross-section.				Strain per square inch.		Elastic limit of strain compared with highest strain.
No. of experiment.	Material.	On specimen.	Time of application.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	Original.	Under strain, (smallest place.)	Released, (smallest place.)	Percentage of original area.	Of original area.	Of reduced area.	
		Lbs.	*m. s.*	*In.*	*In.*		*In.*	*In.*		*In.*	*In.*		*In.*	*In.*	*In.*		*Lbs.*	*Lbs.*	*Per ct.*
		4,600	4 00	.018	......	.18	.000	......	......	.018	......	.18	......	......	......	......	......	......	......
		4,800	2 15	.019	......	.19	.000	......	......	.019	......	.19	......	......	......	......	......	......	......
		*5,000	11 55	.224	......	2.24	.201	......	2.01	.023	......	.23	......	......	......	......	......	......	......
		7,510	5 05	......	......	......	......	......	......	......	......	......	......	......	......	......	84,339	......	64.32
		6,350	26	Broke	......		......	.529	10.58	......	......	......	......	......	.2183 x .2183	53.30	......	133,250	......
176	A co 8	2,400	2 15	.008	......	.08	.000	......	......	.008	......	.08	.2979 x .2988	......	......	......	......	......	......
		2,600	1 00	.010	......	.10	.000	......	......	.010	......	.10	......	......	......	......	......	......	......
		2,800	1 30	.010	......	.10	.000	......	......	.010	......	.10	......	......	......	......	......	......	......
		3,000	2 00	.011	......	.11	.000	......	......	.011	......	.11	......	......	......	......	......	......	......
		3,200	3 05	.014	......	.14	.000	......	......	.014	......	.14	......	......	......	......	......	......	......
		3,400	2 00	.014	......	.14	.000	......	......	.014	......	.14	......	......	......	......	......	......	......
		3,600	2 30	.014	......	.14	.000	......	......	.014	......	.14	......	......	......	......	......	......	......
		3,800	3 55	.014	......	.14	.000	......	......	.014	......	.14	......	......	......	......	......	......	......
		†14,000	51 30	.238	......	2.38	.221	......	2.21	.017	......	.17	......	......	......	......	......	......	......
		6,150	7 00	......	......	......	......	......	......	......	......	......	......	......	......	......	67,968	......	62.92
		4,810	18	Broke	......	......	......	.910	18.20	......	......	......	......	......	.195 x .197	42.08	......	125,210	......
177	A co 18 ✱.....	3,000	2 30	.011	......	.11	.000	......	......	.011	......	.11	.2985 x .299	......	......	......	......	......	......
		3,400	1 30	.013	......	.13	.000	......	......	.013	......	.13	......	......	......	......	......	......	......
		3,600	3 00	.014	......	.14	.000	......	......	.014	......	.14	......	......	......	......	......	......	......
		3,800	2 30	.015	......	.15	.000	......	......	.015	......	.15	......	......	......	......	......	......	......
		4,000	3 35	.016	......	.16	.000	......	......	.016	......	.16	......	......	......	......	......	......	......
		4,200	2 45	.016	......	.16	.000	......	......	.016	......	.16	......	......	......	......	......	......	......
		4,400	2 15	.018	......	.18	.000	......	......	.018	......	.18	......	......	......	......	......	......	......
		4,600	3 30	.018	....	.18	.000	......	......	.018	......	.18	......	......	......	......	......	......	......
		4,800	3 35	.018	......	.18	.000	......	......	.018	......	.18	......	......	......	......	......	......	......
		5,000	7 45	.197	......	1.97	.175	......	1.75	.022	......	.22	......	......	......	......	......	......	......

		7,525	6 50														843,123		65.11
		6,510	20	Broke			1.507		15.07						.223 x .228	56.97		128,038	
178	A co 25 *.....	2,400	1 30	.010		.10	.000			.010		.10	.2975 x .2992						
		2,600	1 33	.010		.10	.000			.010		.10							
		2,800	1 15	.011		.11	.000			.011		.11							
		3,000	3 00	.011		.11	.000			.011		.11							
		3,200	2 40	.012		.12	.000			.012		.12							
		3,400	1 40	.014		.14	.000			.014		.14							
		3,600	2 45	.014		.14	.000			.014		.14							
		3,800	3 00	.014		.14	.000			.014		.14							
		4,000	2 30	.015		.15	.000			.015		.15							
		4,200	14 00	.227		2.27	.210		2.10	.017		.17							
		6,375	5 00														71,620		64.31
		5,250	21	Broke				.608	12.16						.208 x .214	50.01		117,945	
179	A co 39 *....	3,000	1 35	.010		.10	.000			.010		.10	.2995 x .2985						
		3,200	1 15	.010		.10	.000			.010		.10							
		3,400	1 30	.012		.12	.000			.012		.12							
		3,600	1 10	.013		.13	.000			.013		.13							
		3,800	1 30	.014		.14	.000			.014		.14							
		4,000	3 15	.016		.16	.000			.016		.16							
		4,200	3 00	.016		.16	.000			.016		.16							
		4,400	2 43	.017		.17	.000			.017		.17							
		4,600	2 30	.018		.18	.000			.018		.18							
		4,800	3 30	.018		.18	.000			.018		.18							
		5,000	27 20	.094		.94	.074		.74	.020		.20							
		7,990	5 25														89,373		61.32
		6,900	18	Broke				.656	13.12						.227 x .227	57.64		133,905	
180	S P R 31 *...	2,200	1 45	.007		.07	.000			.007		.07	.289 x .2985						
		2,600	1 50	.007		.07	.000			.007		.07							
		2,800	2 40	.008		.08	.000			.008		.08							
		3,000	2 00	.009		.09	.000			.009		.09							
		3,200	31 00	.081		.81	.070		.70	.011		.11							
		6,405	6 00														74,246		48.40
		5,075	33	Broke				.700	14.00						.196 x .195	44.19		13,278	
181	B S co 4.......	1,800	1 30	.004		.04	.000			.004		.04	.2985 x .2963						
		2,000	2 35	.008		.08	.000			.008		.08							
		2,200	3 45	.008		.08	.000			.008		.08							
		2,400	46 10	.167		1.67	.156		1.56	.011		0.11							
		4,530	7 00														51,803		50.77
		3,390	28	Broke				1.038	20.76						.185 x .185	39.14		99,050	

* Extension was very slow under this strain for about two minutes, then became quicker, finally ceasing at the extent noted.

† Entension, after nearly ceasing at this strain, increased in rapidity, ceasing finally at extent noted.

TABLE 5.—*TENSILE TESTS of square gun-wires of various manufacture*—Continued.

Mark on specimen designating—		Strain.		Elongation under strain.			Elongation after release.			Resilience.			Dimensions of cross-section.				Strain per square inch.		Elastic limit of strain compared with highest strain.
No. of experiment.	Material.	On specimen.	Time of application.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	Original.	Under strain, (smallest place.)	Released, (smallest place.)	Percentage of original area.	Of original area.	Of reduced area.	
		Lbs.	*m. s.*	*In.*	*In.*		*In.*	*In.*		*In.*	*In.*		*In.*	*In.*	*In.*		*Lbs.*	*Lbs.*	*Per ct.*
182	B S co 5*	2,000	1 45	.006	......	.06	.000	......	......	.006	......	.06	.2982 x .2988	......	......	......	......	......	......
		2,200	1 33	.008	......	.08	.000	......	......	.008	......	.08	......	......	......	......	......	......	......
		2,400	2 00	.008	......	.08	.000	......	......	.008	......	.08	......	......	......	......	......	......	......
		2,600	1 25	.008	......	.08	.000	......	......	.008	......	.08	......	......	......	......	......	......	......
		2,800	2 00	.008	......	.08	.000	......	......	.008	......	.08	......	......	......	......	......	......	......
		3,000	2 00	.009	......	.09	.000	......	......	.009	......	.09	......	......	......	......	......	......	......
		3,200	1 45	.009	......	.09	.000	......	......	.009	......	.09	......	......	......	......	......	......	......
		3,400	2 45	.011	......	.11	.000	......	......	.011	......	.11	......	......	......	......	......	......	......
		3,600	6 30	.155	......	1.55	.139	......	1.39	.016	......	0.16	......	......	......	......	......	......	......
		6,375	4 35	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	54.90
		P.S. lost	......	Broke	......	......	......	.697	13.94	......	......	......	......	......	.224 x .224	......	......	......	......
183	B S co 6*	2,400	1 30	.009	......	.09	.000	......	......	.009	......	.09	.2955 x .297	......	......	......	......	......	......
		2,600	24 40	.162	......	1.62	.149	......	1.49	.013	......	0.13	......	......	......	......	......	......	......
		4,950	7 28	......	......	......	......	......	......	......	......	......	......	......	......	......	56,394	......	49.49
		4,000	15	Broke	......	......	......	1.077	21.54	......	......	......	......	......	.200 x .201	45.81	......	99,502	......
210	From ch'ge 900	3,000	1 50	.009	......	.09	.000	......	......	.009	......	.09	.3008 x .2985	......	......	......	......	......	......
		3,200	3 10	.010	......	.10	.005	......	.05	.005	......	.05	......	......	......	......	......	......	......
		3,400	7 15	.024	......	.24	.015	......	.15	.009	......	.09	......	......	......	......	......	......	......
		7,365	6 50	......	......	......	......	......	......	......	......	......	......	......	......	......	81,998	......	43.45
		6,740	10	Broke	......	......	1.843	.808	18.43	......	......	......	......	......	......	......	......	......	......
215	A co 85*	3,000	3 00	.011	......	.11	.001	......	.01	.010	......	.10	.2978 x .3006	......	......	......	......	......	......
		3,200	2 45	.015	......	.15	.004	......	.04	.011	......	.11	......	......	......	......	......	......	......
		7,950	11 20	......	......	......	.724	......	7.24	......	......	......	......	......	......	......	......	......	......
		8,185	2 45	......	......	......	......	......	......	......	......	......	......	......	......	......	82,113	......	36.65
		7,400	10	Broke	......	......	1.375	.525	13.75	......	......	......	......	......	.2455 x .2473	67.37	......	82,113	......
216	A co 91*	2,600	3 30	.011	......	.11	.001	......	.01	.010	......	.10	.2983 x .3016	......	......	......	......	......	......

		2, 800	2 00	.014		.14	.003		.03	.011		.11							
		3, 000	3 30	.014		.14	.003		.03	.011		.11							
		3, 200	3 00	.015		.15	.003		.03	.012		.12							
		3, 400	3 30	.016		.16	.003		.03	.013		.13							
		3, 600	3 00	.016		.16													
		3, 800	2 00	.017		.17	.004		.04	.013		.13							
		4, 000	2 00	.019		.19	.004		.04	.015		.15							
		4, 200	2 00	.020		.20	.004		.04	.016		.16							
		4, 400	2 15	.020		.20	.004		.04	.016		.16							
		4, 600	2 00	.022		.22	.004		.04	.018		.18							
		4, 800	15 00	.074		.74	.056		.56	.018		.18							
		8, 000	4 00				.887		8.87										
		8, 200	1 45														91, 144		53.66
		7, 500	20	Broke			1.425	.605	14.25						.2437 x .2455	66.50		125, 358	
217	A co 138 *	2, 500	3 00	.010		.10	.000			.010		.11	.2975 x .2985						
		2, 800	3 15	.010		.10	.000			.010		.10							
		3, 000	4 00	.010		.10	.000			.010		.10							
		3, 400	2 00	.015		.15	.000			.015		.15							
		3, 600	2 30	.015		.15	.000			.015		.15							
		3, 800	2 30	.015		.15	.000			.015		.15							
		4, 000	3 00	.015		.15	.000			.015		.15							
		4, 200	3 20	.016		.16	.000			.016		.16							
		4, 400	9 30	.222		2.22	.199		1.99	.023		1.23							
		6, 450	4 00				.892		8.92										
		6, 700	5 30				1.799		17.99								75, 201		63.43
		5, 600	25	Broke			1.864	.850	18.64						.2217 x .222	53.76		11, 769	
218	A co 144 *	2, 500	2 30	.007		.07	.000			.007		.07	.2991 x .301						
		2, 800	2 30	.007		.07	.000			.007		.07							
		3, 000	1 30	.009		.09	.000			.009		.09							
		3, 200	2 00	.010		.10	.000			.010		.10							
		3, 400	2 30	.013		.13	.000			.013		.13							
		3, 600	2 00	.013		.13	.000			.013		.13							
		3, 800	2 30	.015		.15	.000			.015		.15							
		4, 000	2 30	.015		.15	.000			.015		.15							
		4, 200	3 30	.017		.17	.000			.017		.17							
		4. 400	26 00	.198		1.98	.180		1.8	.018		.18							
		6, 500	3 00				.764		7.64										
		6, 750	4 00				1.607		16.07										
		6, 820	30														75, 753		62, 31
		5, 900	15	Broke			1.750	.790	17.50						.2655 x .2257	56.78		98, 459	
219	A co 65 *	2, 600	2 30	.011		.11	.000			.011		.11	.298 x .3004						
		2, 800	2 00	.011		.11	.000			.011		.11							
		3, 000	1 30	.012		.12	.000			.012		.12							
		3, 200	1 45	.013		.13	.000			.013		.13							
		3, 400	1 45	.013		.13	.000			.013		.13							

TABLE 5.—*TENSILE TESTS of square gun-wires of various manufacture*—Continued.

Mark on specimen designating—		Strain.		Elongation under strain.			Elongation after release.			Resilience.			Dimensions of cross-section.				Strain per square inch.		Elastic limit of strain compared with highest strain.
No. of experiment.	Material.	On specimen.	Time of application.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	Original.	Under strain, (smallest place.)	Released, (smallest place.)	Percentage of original area.	Of original area.	Of reduced area.	
		Lbs.	*m. s.*	*In.*	*In.*		*In.*	*In.*		*In.*	*In.*		*In.*	*In.*	*In.*		*Lbs.*	*Lbs.*	*Per ct.*
		3, 600	1 30	.013	......	.13	.000	.....	....	.013	......	.13	....	....	....	....	....	....	....
		3, 800	2 30	.015	......	.15	.000	.....	....	.015	......	.15	....	....	....	....	....	....	....
		4, 000	2 00	.017	......	.17	.000	.....	....	.017	......	.17	....	....	....	....	....	....	....
		4, 200	2 00	.017	......	.17	.000	.....	....	.017	......	.17	....	....	....	....	....	....	....
		4, 400	2 00	.017	......	.17	.000	.....	....	.017	......	.17	....	....	....	....	....	....	....
		4, 600	3 00	.018	......	.18	.000	.....	....	.018	......	.18	....	....	....	....	....	....	....
		4, 800	7 00	.028	......	.28	.010	.....	.1	.018	......	.18	....	....	....	....	....	....	....
		8, 200	11 00	......	......	......	.892	.....	8.92	......	......	......	....	....	....	....	....	....	....
		8, 350	2 15	......	......	......	......	.....	....	......	......	......	....	....	....	....	93, 276	....	55.69
		7, 900	15	Broke	......	......	1.380	.533	13.80	......	......	......	....	....	.2509 x .252	70.63	....	124, 950	....
220	A co 85* TH ...	2, 600	2 00	.007	......	.07	.000	.....	....	.007	......	.07	.298 x .3005	....	....	....	....	....	....
		3, 400	1 30	.013	......	.13	.000	.....	....	.013	......	.13	....	....	....	....	....	....	....
		4, 000	2 45	.016	......	.16	.000	.....	....	.016	......	.16	....	....	....	....	....	....	....
		4, 400	1 50	.018	......	.18	.000	.....	....	.018	......	.18	....	....	....	....	....	....	....
		4, 600	8 00	.020	......	.20	.001	.....	.01	.019	......	.19	....	....	....	....	....	....	....
		4, 800	7 45	.120	......	1.20	.100	.....	1.00	.020	......	.20	....	....	....	....	....	....	....
		8, 540	7 00	......	......	......	.995	.....	9.95	......	......	......	....	....	....	....	....	....	....
		8, 575	1 20	......	......	......	......	.....	....	......	......	......	....	....	....	....	95, 758	....	53.64
		8, 200	10	Broke	......	......	1.348	.5995	13.48	......	......	......	....	....	.2572 x .2547	73.16	....	125, 170	....

TABLE 5 BIS.—*TENSILE TESTS of cylindric steel wires drawn from imported steel and furnished by the Cary Wire Works.*

[Annealed at a heat between the melting-point of bronze and copper.]

Mark on specimen designating—		Strain.		Elongation under strain.			Elongation after release.			Resilience.			Diameter.				Strain per square inch.		Elastic limit of strain compared with highest strain.
No. of experiment.	Material.	On specimen.	Time of application.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	Original.	Under strain, (smallest place.)	Released, (smallest place.)	Percentage of original area.	Of original area.	Of reduced area.	
		Lbs.	*m. s.*	*In.*	*In.*		*In.*	*In.*		*In.*	*In.*		*In.*	*In.*	*In.*		*Lbs.*	*Lbs.*	*Per ct.*
150	C W co 1......	700	......	.0035	......	.035	.000	......	......	.0035	......	.035	.1912	......	......	......	......	......	......
		800	......	.005	......	.05	.000	......	......	.005	......	.05	......	......	......	......	......	......	......
		900	2 00	.0075	......	.075	.000	......	......	.0075	......	.075	......	......	......	......	......	......	......
		1,000	2 30	.009	......	.09	.000	......	......	.009	......	.09	......	......	......	......	......	......	......
		1,100	*2 30	.010	......	.1	.000	......	......	.010	......	.1	......	......	......	......	......	......	......
		1,200	*2 30	.011	......	.11	.000	......	......	.011	......	.11	......	......	......	......	41,772	......	......
		1,300	60 00	.174	......	1.74	.158	......	1.58	.016	......	.16	......	......	......	......	45,253	......	......
		2,210	9 30	Broke	......	......	1.657	......	16.57	......	......	......	......	......	.1376	......	76,931	......	57.46
151	C W co 2......	700	2 30	.005	......	.05	.000	......	......	.005	......	.05	.1912	......	......	......	......	......	......
		800	2 00	.007	......	.07	.000	......	......	.007	......	.07	......	......	......	......	......	......	......
		900	3 00	.010	......	.1	.000	......	......	.010	......	.1	......	......	......	......	......	......	......
		1,000	2 00	.011	......	.11	.000	......	......	.011	......	.11	......	......	......	......	......	......	......
		1,100	*2 30	.012	......	.12	.000	......	......	.012	......	.12	......	......	......	......	......	......	......
		1,200	*2 30	.013	......	.13	.000	......	......	.013	......	.13	......	......	......	......	......	......	......
		1,300	2 45	.013	......	.13	.000	......	......	.013	......	.13	......	......	......	......	45,316	......	......
		1,400	11 00	.017	......	.17	.001	......	.01	.016	......	.16	......	......	......	......	48,802	......	......
		1,500	4 30	.080	......	.8	.037	......	.57	.023	......	.23	......	......	......	......	......	......	......
		3,050	4 00	Broke	......	......	1.112	.528	11.12	......	......	......	......	......	.1672	......	106,319	......	47.54
152	C W co 1.....	700	3 16	.007	......	.07	.000	......	......	.007	......	.07	.1915	......	......	......	......	......	......
		800	3 17	.009	......	.09	.000	......	......	.009	......	.09	......	......	......	......	......	......	......
		900	3 10	.009	......	.09	.000	......	......	.009	......	.09	......	......	......	......	......	......	......
		1,000	3 41	.010	......	.1	.000	......	......	.010	......	.1	......	......	......	......	34,495	......	......
		1,100	4 24	.013	......	.13	.001	......	.01	.012	......	.12	......	......	......	......	37,945	......	......
		1,200	3 25	.013	......	.13	.001	......	.01	.012	......	.12	......	......	......	......	......	......	......
		1,300	8 54	.218	......	2.18	.206	......	2.06	.012	......	.12	......	......	......	......	......	......	......

TABLE 5 BIS.—*TENSILE TESTS of cylindric steel wires drawn from imported steel, &c.*—Continued.

Mark on specimen designating—		Strain.		Elongation under strain.			Elongation after release.			Resilience.			Diameter.				Strain per square inch.		Elastic limit of strain compared with highest strain.
No. of experiment.	Material.	On specimen.	Time of application.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	Original.	Under strain, (smallest place.)	Released, (smallest) place.	Percentage of original area.	Of original area.	Of reduced area.	
		Lbs.	*m. s.*	*In.*	*In.*		*In.*	*In.*		*In.*	*In.*		*In.*	*In.*	*In.*		*Lbs.*	*Lbs.*	*Per ct.*
		1,860	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
		2,060	7 00	Broke	......	......	1.646	.490	16.46	......	......	......	......	......	.1333	......	71,061	......	59.70
153	C W co 2	700	1 52	.005	......	.05	.000	......	......	......	......	......	.1919	......	......	......	......	......	......
		800	1 15	.008	......	.08	.000	......	......	......	......	......	......	......	......	......	......	......	......
		900	1 56	.009	......	.09	.000	......	......	......	......	......	......	......	......	......	......	......	......
		1,000	2 37	.009	......	.09	.000	......	......	......	......	......	......	......	......	......	......	......	......
		1,100	1 44	.010	......	.1	.000	......	......	......	......	......	......	......	......	......	......	......	......
		1,200	1 57	.012	......	.12	.000	......	......	......	......	......	......	......	......	......	......	......	......
		1,300	3 35	.013	......	.13	.000	......	......	......	......	......	......	......	......	......	44,925	......	......
		1,400	4 32	.103	......	1.03	.084	......	.84	.019	......	.19	......	......	......	......	48,380	......	......
		2,800	4 17	Broke	......	......	1.261	.479	12.61	......	......	......	......	......	.1612	......	96,761	......	48.21

TABLE 6.—*TENSILE TESTS of specimens formed of gun-wires united with a bronze composed of five parts of copper to one of tin.*

[For arrangement of wires, see Plate 3, Figs. 2 and 3.]

Mark on specimen designating—		Strain.		Elongation under strain.			Elongation after release.			Resilience.			Diameter.				Strain per square inch.		Elastic limit of strain compared with highest strain.
No. of experiment.	Material.	On specimen.	Time of application.	In 1.7 inches of original length.	In 2 inches of original length.	Percentage of original length.	In 1.7 inches of original length.	In 2 inches of original length.	Percentage of original length.	In 1.7 inches of original length.	In 2 inches of original length.	Percentage of original length.	Original.	Under strain, (smallest place.)	Released, (smallest place.)	Percentage of original area.	Of original area.	Of reduced area.	
		Lbs.	*m. s.*	*In.*	*In.*		*In.*	*In.*		*In.*	*In.*		*In.*	*In.*	*In.*		*Lbs.*	*Lbs.*	*Per ct.*
184	C K........	10,000	5 00	......	.001	.05	......	.000	......	......	.001	.05	.798	......	......	......	......	......	......
		10,500	3 00	......	.001	.05	......	.000	......	......	.001	.05	......	......	......	......	......	......	......
		11,000	2 00	......	.001	.05	......	.000	......	......	.001	.05	......	......	......	......	......	......	......
		11,500	1 20	......	.001	.05	......	.000	......	......	.001	.05	......	......	......	......	......	......	......
		12,000	1 30	......	.001	.05	......	.000	......	......	.001	.05	......	......	......	......	......	......	......
		12,500	2 10	......	.001	.05	......	.000	......	......	.001	.05	......	......	......	......	......	......	......
		13,000	2 00	......	.001	.05	......	.000	......	......	.001	.05	......	......	......	......	......	......	......
		13,500	1 45	......	.001	.05	......	.000	......	......	.001	.05	......	......	......	......	......	......	......
		14,000	2 00	......	.001	.05	......	.000	......	......	.001	.05	......	......	......	......	......	......	......
		14,500	2 00	......	.001	.05	......	.000	......	......	.001	.05	......	......	......	......	......	......	......
		15,000	2 00	......	.001	.05	......	.000	......	......	.001	.05	......	......	......	......	......	......	......
		15,500	1 30	......	.001	.05	......	.000	......	......	.001	.05	......	......	......	......	......	......	......
		16,000	1 30	......	.001	.05	......	.000	......	......	.001	.05	......	......	......	......	......	......	......
		16,500	1 30	......	.001	.05	......	.000	......	......	.001	.05	......	......	......	......	......	......	......
		17,000	1 30	......	.001	.05	......	.000	......	......	.001	.05	......	......	......	......	......	......	......
		17,500	2 00	......	.001	.05	......	.000	......	......	.001	.05	......	......	......	......	......	......	......
		18,000	2 00	......	.001	.05	......	.000	......	......	.001	.05	......	......	......	......	......	......	......
		18,500	2 00	......	.001	.05	......	.000	......	......	.001	.05	......	......	......	......	......	......	......
		19,000	2 00	......	.001	.05	......	.000	......	......	.001	.05	......	......	......	......	......	......	......
		19,500	2 30	......	.001	.05	......	.000	......	......	.001	.05	......	......	......	......	......	......	......
		20,000	1 30	......	.001	.05	......	.000	......	......	.001	.05	......	......	......	......	......	......	......
		20,500	2 00	......	.001	.05	......	.000	......	......	.001	.05	......	......	......	......	......	......	......
		21,000	1 30	......	.001	.05	......	.000	......	......	.001	.05	......	......	......	......	......	......	......
		21,500	1 30	......	.001	.05	......	.000	......	......	.001	.05	......	......	......	......	......	......	......
		22,000	2 00	......	.001	.05	......	.000	......	......	.001	.05	......	......	......	......	......	......	......
		22,500	2 00	......	.001	.05	......	.000	......	......	.001	.05	......	......	......	......	......	......	......

TABLE 6.—*TENSILE TESTS of specimens formed of gun-wires united with bronze*—Continued.

Mark on specimen designating—		Strain.		Elongation under strain.			Elongation after release.			Resilience.			Diameter.				Strain per square inch.		Elastic limit of strain compared with highest strain.
No. of experiment.	Material.	On specimen.	Time of application.	In 1.7 inches of original length.	In 2 inches of original length.	Percentage of original length.	In 1.7 inches of original length.	In 2 inches of original length.	Percentage of original length.	In 1.7 inches of original length.	In 2 inches of original length.	Percentage of original length.	Original.	Under strain, (smallest place.)	Released, (smallest place.)	Percentage of original area.	Of original area.	Of reduced area.	
		Lbs.	*m. s.*	*In.*	*In.*		*In.*	*In.*		*In.*	*In.*		*In.*	*In.*	*In.*		*Lbs.*	*Lbs.*	*Per ct.*
		23,000	1 30	......	.001	.05	......	.000	......	......	.001	.05	......	......	......	......	......	......	......
		23,500	1 30	......	.001	.05	......	.000	......	......	.001	.05	......	......	......	......	......	......	......
		24,000	2 00	......	.001	.05	......	.000	......	......	.001	.05	......	......	......	......	......	......	......
		24,500	1 30	......	.001	.05	......	.000	......	......	.001	.05	......	......	......	......	......	......	......
		25,000	3 30	......	.015	.75	......	.009	.45	......	.006	.30	......	......	......	......	......	......	......
		47,650	......	......	Broke	......	......	.311	15.55	......	......	......	......	......	.739 and .752	......	95,273	......	52.46
185	C L	16,000	5 00	......	.000	......	......	.000	......	......	.000	......	.7973	......	......	......	......	......	......
		17,000	3 00	......	.000	......	......	.000	......	......	.000	......	......	......	......	......	......	......	......
		18,000	9 00	......	.025	1.25	......	.022	1.10	......	.003	.15	......	......	......	......	......	......	......
		32,640	7 20	......	......	......	......	......	......	......	......	......	......	......	......	......	65,375	......	53.61
		28,400	1 00	......	Broke	......	......	.590	29.50	......	......	......	......	......	......	......	......	......	......
186	C Hco 5 I	14,200	4 30	......	.024	1.20	......	.0235	1.175	......	.0005	.045	.7975	......	......	......	......	......	......
		25,100	6 30	......	......	......	......	......	......	......	......	......	......	......	......	......	50,248	......	51.79
		21,300	2 05	......	Broke	......	......	.700	35.00	......	......	......	......	......	......	......	......	......	......
187	Nco I	12,250	6 20	......	.017	.85	......	.016	.80	......	.217	.05	.798	......	......	......	......	......	......
		24,400	3 45	......	......	......	......	......	......	......	......	......	......	......	......	......	48,786	......	49.79
		8,150	2 00	......	Broke	......	......	.717	35.85	......	......	......	......	......	......	......	......	......	......
188	C Sco 5	18,000	6 00	......	.009	.45	......	.006	.30	......	.003	.15	.7975	......	......	......	......	......	......
		18,500	4 00	......	.011	.55	......	......	......	......	.011	.55	......	......	......	......	......	......	......
		19,500	6 00	......	.013	.65	......	......	......	......	.013	.65	......	......	......	......	......	......	......
		20,000	3 00	......	.015	.75	......	.013	.65	......	.002	.10	......	......	......	......	91,838	......	......
		45,875	5 20	......	.196	9.80	......	......	......	......	.196	9.80	......	......	......	......	......	......	39.23
211	From charge 900, (Trouton.)	24,000	......	......	......	......	......	.176	8.80	......	......	......	.796	......	......	......	......	......	......
		24,800	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
		41,000	5 30	......	......	......	......	......	......	......	......	......	......	?......	......	......	......	......	55.68
		53,600	......	......	......	......	......	......	......	......	......	......	......	......	.748 and .751	......	107,710	......	......

212	A co 86*	20,000			.000			.000					.815						
		25,000			.000			.000											
		28,000			.000			.000											
		30,000			.000			.000											
		32,000			.001	.05		.000			.001	.05							
		34,000			.001	.05		.000			.001	.05							
		37,000			.002	.10		.000			.002	.10							
		39,000			.003	.15		.000			.003	.15							
		40,000			.003	.15		.000			.003	.15							
		43,000	2 40		.0045	2.25		.000			.0045	.225							
		45,000	2 55		.005	.25		.000			.005	.25							
		40,000						.000											
		47,000						.000											
		48,000	3 40		.009	.45		.000			.009	.45							
		50,000			.009	.45		.000			.009	.45							
		52,000			.010	.50		.000			.010	.50							
		55,000	3 55		.014	.70		.006	.30		.008	.40							
		56,840			Broke			.009	.45								108,955		91.31
213	A co 86 *	17,000	5 00		.001	.05		.000			.001	.05	.649						
		20,000	2 50		.000														
		20,500	3 30		.020	1.00		.015	.75		.005	.25							
		25,000	4 00		.040	2.00		.035	1.75		.005	1.25							
		33,570	4 00		.125	6.75					.125	6.75			.6345		10,148		60.20
214	A co 86 *	12,000	2 30		.004	.20		.000			.004	.20	.533						
		13,000	2 00		.004	.20		.000			.004	.20							
		14,000	2 00		.004	.20		.000											
		15,000	2 00		.005	.25		.000			.005	.25							
		16,000	2 00		.005	.25		.000			.005	.25							
		17,000	2 00		.005	.25		.000			.005	.25							
		18,000	2 00		.007	.35		.000			.007	.35							
		19,000	2 00		.008	.40		.000			.008	.40							
		20,000	2 30		.009	.45		.002	.10		.007	.35							
		20,000	2 20		.014	.70		.004	.20		.010	.50							
		29,100	1 50		Broke			.073	3.65						.525		130,421		67.01
221	N co I	3,000	2 00	.000									.566 and .567						
		4,000	2 00	.000															
		4,500	2 30	.000															
		5,000	3 00	.004		.23	.000			.004		.23							
		5,500	3 30	.005		.44	.000			.005		.44							
		6,000	4 00	.005		.44	.000			.005		.44							
		6,500	1 50	.005		.44	.000			.005		.44							
		7,000	5 00	.024		1.41	.015		.88	.009		.53							
		7,500	3 25	.031		1.82	.026		1.52	.005		.30							
		11,750	5 10														466,176		57.87
		6,100	1 15	Broke			.436		25.63						464 and .472			354,585	

TABLE 6.—*TENSILE TESTS of specimens formed of gun-wires united with bronze*—Continued.

Mark on specimen designating—		Strain.		Elongation under strain.			Elongation after release.			Resilience.			Diameter.				Strain per square inch.		Elastic limit of strain compared with highest strain.
No. of experiment.	Material.	On specimen.	Time of application.	In 1.8 inches of original length.	In 2 inches of original length.	Percentage of original length.	In 1.8 inches of original length.	In 2 inches of original length.	Percentage of original length.	In 1.8 inches of original length.	In 2 inches of original length.	Percentage of original length.	Original.	Under strain, (smallest place.)	Released, (smallest place.)	Percentage of original area.	Of original area.	Of reduced area.	
		Lbs.	*m. s.*	*In.*	*In.*		*In.*	*In.*		*In.*	*In.*		*In.*	*In.*	*In.*		*Lbs.*	*Lbs.*	*Per ct.*
222	From charge 900, (Trenton.)	10, 000	2 00	.002	......	.11	.000	......	......	.002	......	.11	.796	......	......	......	......	......	......
		10, 500	3 00	.002	......	.11	.000	......	......	.002	......	.11	......	......	......	......	......	......	......
		11, 000	2 00	.002	......	.11	.000	......	......	.002	......	.11	......	......	......	......	......	......	......
		12, 000	2 30	.002	......	.11	.000	......	......	.002	......	.11	......	......	......	......	......	......	......
		13, 000	2 30	.002	......	.11	.000	......	......	.002	......	.11	......	......	......	......	......	......	......
		14, 000	2 00	.002	......	.11	.000	......	......	.002	......	.11	......	......	......	......	......	......	......
		15, 000	2 00	.002	......	.11	.000	......	......	.002	......	.11	......	......	......	......	......	......	......
		16, 000	2 00	.002	......	.11	.000	......	......	.002	......	.11	......	......	......	......	......	......	......
		17, 000	2 00	.002	......	.11	.000	......	......	.002	......	.11	......	......	......	......	......	......	......
		18, 000	2 00	.002	......	.11	.000	......	......	.002	......	.11	......	......	......	......	......	......	......
		19, 000	2 00	.002	......	.11	.000	......	......	.002	......	.11	......	......	......	......	......	......	......
		20, 000	2 00	.002	......	.11	.000	......	......	.002	......	.11	......	......	......	......	......	......	......
		21, 000	2 00	.002	......	.11	.000	......	......	.002	......	.11	......	......	......	......	......	......	......
		22, 000	3 30	.006	......	.33	.002	......	.11	.004	......	.22	......	......	......	......	......	......	......
		23, 000	3 00	.008	......	.44	.004	......	.22	.004	......	.22	......	......	......	......	......	......	......
		24, 000	3 30	.010	......	.55	.006	......	.33	.004	......	.22	......	......	......	......	......	......	......
		25, 000	3 30	.012	......	.66	.008	......	.44	.004	......	.22	......	......	......	......	50, 237	......	......
		42, 300	7 20	......	......	......	.097	......	5.38	......	......	......	......	......	......	......	90, 720	......	52.01

TABLE 7.—*TENSILE TESTS of turned specimens of Bessemer steel, from the works of John A. Griswold & Co., annealed at a heat between the melting-points of bronze and copper, without oxidation of surface.*

Mark on specimen designating— No. of experiment.	Mark on specimen designating— Material.	Strain. On specimen.	Strain. Time of application.	Elongation under strain. In 10 inches of original length.	Elongation under strain. In 2 inches of original length.	Elongation under strain. Percentage of original length.	Elongation after release. In 10 inches of original length.	Elongation after release. In 2 inches of original length.	Elongation after release. Percentage of original length.	Resilience. In 2 inches of original length.	Resilience. In 5 inches of original length.	Resilience. Percentage of original length.	Dimensions of cross-section. Original diameter.	Dimensions of cross-section. Diameter under strain, (smallest place.)	Dimensions of cross-section. Diameter after release, (smallest place.)	Dimensions of cross-section. Percentage of original area.	Strain per square inch. Of original area.	Strain per square inch. Of reduced area.	Elastic limit of strain compared with highest strain.	Remarks.
		Lbs.	*m. s.*	*In.*	*In.*		*In.*	*In.*		*In.*	*In.*		*In.*	*In.*	*In.*		*Lbs.*	*Lbs.*	*Per ct.*	
201	BES. 1	6, 000	4 20		Began			.000					.396							For the form of these specimens, see Plate 3, Fig. 1.
		10, 620	4 50		.310	15. 50		.000		.310		15. 50		.351			86, 116		56. 50	
		9, 600	1 18					.380	19. 00						.312			125, 570		
202	BES. 3	6, 500	3 20		Began			.000					.399							
		11, 000	7 30		.389	19. 45		.000		.389		19. 45		.356			87, 975		59. 09	
		9, 740	1 45					.500	25. 00						.305			133, 310		
203	BES. 4	6, 400	3 00		Began			.000					.393							
		11, 100	6 30		.324	16. 20		.000		.324		16. 20		.358			91, 506		57. 66	
		9, 425	2 30					.474	23. 70						.287			145, 690		
204	BES. 5	7, 500	4 00		Began			.000					.399							
		12, 800	6 10		.348	17. 40		.000		.348		17. 40		.360			10, 247		58. 59	
		11, 685	2 10					.432	21. 60						.321			144, 390		
205	BES. 6	6, 200	3 20		Began			.000					.398							
		11, 435	5 18		.341	17. 05		.000		.341		17. 05		.359			91, 914		54. 22	
		10, 050	2 20					.469	23. 45						.304			138, 460		
206	BES. 7	6, 180	2 00		Began			.000					.398							
		11, 125	4 05		.325	16. 25		.000		.325		16. 25		.355			89, 422		55. 55	
		10, 025	1 10					.409	20. 45						.311			131, 970		
207	BES. 8	6, 100	2 00		Began			.000					.398							
		9, 490	4 20		.394	19. 70		.000		.394		19. 70		.349			76, 280		64. 28	
		7, 950	1 55					.495	24. 75						.282			127, 210		
208	BES. 12	6, 125	2 00		Began			.000					.391							
		10, 575	4 22		.394	19. 70		.000		.394		19. 70		.351			88, 072		57. 93	
		9, 050	3 05					.516	25. 80						.295			132, 400		
209	BES. 16	6, 440	2 30		Began			.000					.398							
		11, 470	5 50		.393	19. 65		.000		.394		19. 65		.354			92, 195		56. 15	
		10, 000	1 35					.492	24. 60						.303			138, 670		

TABLE 8.—*TENSILE TESTS of square gun-wires of various manufacture.*

[For explanation of marks, see pages 136 to 140, inclusive.]

Mark on specimen designating—		Strain.		Elongation under strain.			Elongation after release.			Resilience.			Dimensions of cross-section.				Strain per square inch.		Elastic limit of strain compared with highest strain.
No. of experiment.	Material.	On specimen.	Time of application.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 2.5 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	Original.	Under strain, (smallest place.)	Released, (smallest place.)	Percentage of original area.	Of original area.	Of reduced area.	
		Lbs.	*m. s.*	*In.*	*In.*		*In.*	*In.*		*In.*	*In.*		*In.*	*In.*	*In.*		*Lbs.*	*Lbs.*	*Per ct.*
191	S P R 42*	3,000	2 40		.004	.08		.000			.004	.08	.2964 x .2973						
		3,400	2 00		.007	.14		.000			.007	.14							
		3,600	2 35		.008	.16		.000			.008	.16							
		3,800	2 00		.008	.16		.000			.008	.16							
		4,000	2 05		.010	.20		.000			.010	.20							
		4,200	9 30		.067	1.34		.057	1.14		.010	.20							
		7,885	8 50														89,481		52.00
		7,030	15		Broke.		.414	1.041	20.82						.2303 x .2305			132,430	
192	S P R 58 *	3,000	2 25		.005	.10		.000			.005	.10	.3019 x .3004						
		3,200	1 30		.006	.12		.000			.006	.12							
		3,400	1 20		.007	.14		.000			.007	.14							
		3,600	2 00		.008	.16		.000			.008	.16							
		3,800	3 05		.014	.28		.008	.16		.006	.12							
		4,000	7 40		.060	1.20		.050	1.00		.010	.20							
		7,650	6 00														84,352		45.75
		7,000	20		Broke.		.404	.943	18.86						.2305 x .2336			130,003	
193	S P R 43*.	2,600	2 05		.004	.08		.000			.004	.08	.2992 x .3009						
		2,800	2 20		.005	.10		.000			.005	.10							
		3,000	3 00		.007	.14		.000			.007	.14							
		3,200	2 30		.008	.16		.000			.008	.16							
		3,400	2 00		.008	.16		.000			.008	.16							
		3,600	2 05		.008	.16		.000			.008	.16							
		3,800	2 00		.013	.26		.006	.12		.007	.14							
		4,000	6 00		.071	1.42		.061	1.22		.010	.20							

		7,550	6 00														83,861		48.34
		6,975	20		Broke		.361	.900	18.00						.232 x .2315			127,123	
194	S P R 47*.	3,000	2 00		.006	.12		.000			.006	.12	.297 x .2084						
		3,200	2 40		.007	.14		.000			.007	.14							
		3,400	2 50		.007	.14		.000			.007	.14							
		3,600	2 35		.007	.14		.000			.007	.14							
		3,800	1 45		.007	.14		.000			.007	.14							
		4,000	2 40		.008	.16		.000			.008	.16							
		4,200	6 00		.020	.40		.010	.20		.010	.20							
		8,700	3 15														98,166		47.13
		8,300	15		Broke		.305	.729	14.58						.2465 x .2465			136,581	
195	S P R 48 *.	3,000	2 30		.004	.08		.000			.004	.08	.2943 x .2953						
		3,200	2 00		.005	.10		.000			.005	.10							
		3,400	2 15		.005	.10		.000			.005	.10							
		3,600	3 00		.007	.14		.000			.007	.14							
		3,800	3 20		.007	.14		.000			.007	.14							
		4,000	3 00		.007	.14		.000			.007	.14							
		4,200	3 10		.009	.18		.000			.009	.18							
		4,400	2 20		.010	.20		.000			.010	.20							
		4,600	12 00		.149	2.98		.139	2.78		.010	.20							
		6,540	3 00														75,253		68.81
		5,300	14		Broke.		.475	1.140	22.80						.2065 x .2065			124,524	
196	S P R 46*.	3,200	2 05		.009	.18		.000			.009	.18	.2946 x .2945						
		3,400	2 20		.009	.18		.000			.009	.18							
		3,600	2 08		.009	.18		.000			.009	.18							
		3,800	1 35		.009	.18		.000			.009	.18							
		4,000	1 45		.009	.18		.000			.009	.18							
		4,200	2 30		.012	.24		.004	.08		.008	.16							
		4,400	3 10		.044	.88		.033	.66		.011	.22							
		8,775	4 30		Broke			.475	.950						.2665 x .264		10,115		46.72
197	S P R 49*.	2,600	2 30		.005	.10		.000			.005	.10	.297 x .296						
		2,800	2 30		.006	.12		.000			.006	.12							
		3,000	2 45		.006	.12		.000			.006	.12							
		3,200	2 10		.006	.12		.000			.006	.12							
		3,400	2 20		.007	.14		.000			.007	.14							
		3,600	3 00		.007	.14		.000			.007	.14							
		3,800	3 05		.008	.16		.000			.008	.16							
		4,000	4 10		.008	.16		.000			.008	.16							
		4,200	2 50		.008	.16		.000			.008	.16							
		4,400	20 00		.143	2.86		.131	2.62		.012	.24							
		6,350	4 55														72,233		64.57
		5,160	20		Broke		.462	1.169	23.38						.1965 x .1987			130,641	

TABLE 8.—*TENSILE TESTS of square gun-wires of various manufacture*—Continued.

Mark on specimen designating—		Strain.		Elongation under strain.			Elongation after release.			Resilience.			Dimensions of cross-section.				Strain per square inch.		Elastic limit of strain compared with highest strain.
No. of experiment.	Material.	On specimen.	Time of application.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 2.5 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	Original.	Under strain, (smallest place.)	Released, (smallest place.)	Percentage of original area.	Of original area.	Of reduced area.	
		Lbs.	*m. s.*	*In.*	*In.*		*In.*	*In.*		*In.*	*In.*		*In.*	*In.*	*In.*		*Lbs.*	*Lbs.*	*Per ct.*
198	A co 45*	3,000	2 10		.006	.12		.000			.006	.12	.2968 x .2959						
		3,200	2 30		.006	.12		.000			.006	.12							
		3,400	2 00		.007	.14		.000			.007	.14							
		3,600	2 00		.007	.14		.000			.007	.14							
		3,800	2 10		.008	.16		.000			.008	.16							
		4,000	2 30		.009	.18		.000			.009	.18							
		4,200	2 40		.009	.18		.000			.009	.18							
		4,400	35 00		.047	.94					.047	.94							
		7,500	4 20														85,398		54.67
		6,485	25		Broke		.450	1.030	20.60						.203 x .203			157,365	
199	A co 73*	3,000	2 22		.005	.10		.000			.005	.10	.2951 x .2951						
		3,200	2 10		.005	.10		.000			.005	.10							
		3,400	2 00		.006	.12		.000			.006	.12							
		3,600	2 18		.006	.12		.000			.006	.12							
		3,800	2 30		.007	.14		.000			.007	.14							
		4,000	2 15		.007	.14		.000			.007	.14							
		4,200	2 12		.007	.14		.000			.007	.14							
		4,400	3 00		.008	.16		.001	.02		.007	.14							
		4,600	9 30		.100	2.00		.089	1.78		.011	.22							
		7,340	6 40														84,286		60.63
		6,300	20		Broke.		.468	1.014	20.28						.222 x .224			126,689	
200	S P R 7	3,000	2 40		.003	.06		.000			.003	.06	.3007 x .2997						
		3,200	3 00		.004	.08		.000			.004	.08							
		3,400	6 05		.106	2.12		.098	1.96		.008	.16							
		5,650																	
		5,750	5 40														63,804		57.39
		4,545	55		Broke		.535	1.275	25.50						.1954 x .205			113,460	

TABLE 8.—*TENSILE TESTS of square gun-wi e of various manufacture*—Continued.

Mark on specimen designating—		Strain.		Elongation under strain.			Elongation after release.			Resilience.			Dimensions of cross-section.				Strain per square inch.		Elastic limit of strain compared with highest strain.
No. of experiment.	Material.	On specimen.	Time of application.	In 10 inches of original length.	In 3 inches of original length.	Percentage of original length.	In 1.5 inches of original length.	In 3 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 3 inches of original length.	Percentage of original length.	Original.	Under strain, (smallest place.)	Released, (smallest place.)	Percentage of original area.	Of original area.	Of reduced area.	
		Lbs.	*m. s.*	*In.*	*In.*		*In.*	*In.*		*In.*	*In.*		*In.*	*In.*	*In.*		*Lbs.*	*Lbs.*	*Per. ct.*
190	S P R 58 *	3,000	4 00	......	.002	.06	......	.000	......	......	.002	.06	.3006 x .3017	......	......	......	......	......	......
		3,200	1 20	......	.002	.06	......	.000	......	......	.002	.06	......	......	......	......	......	......	......
		3,400	2 12	......	.003	.09	......	.000	......	......	.003	.09	......	......	......	......	......	......	......
		3,600	2 45	......	.005	.16	......	.000	......	......	.005	.16	......	......	......	......	......	......	......
		3,800	4 00	......	.006	.19	......	.000	......	......	.006	.19	......	......	......	......	......	......	......
		4,000	6 20	......	.038	1.26	......	.0335	1.11	......	.0045	.15	......	......	......	......	......	......	......
		7,625	7 20	......	......	......	......	......	......	......	......	......	......	......	......	......	84,076	......	52.46
		6,725	1 45	......	Broke	......	.268	.633	......	......	......	......	......	......	.224 x .230	......	......	130,512	......

TABLE 9.—*TENSILE TESTS of various unannealed gun-wires of different manufacture.*

[For explanation of marks, see pages 136 to 140, inclusive.]

Mark on specimen designating—		Strain.		Elongation under strain.			Elongation after release.			Resilience.			Dimensions of cross-section.				Strain per square inch.		Elastic limit of strain compared with highest strain.
No. of experiment.	Material.	On specimen.	Time of application.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	Original.	Under strain, (smallest place.)	Released, (smallest place.)	Percentage of original area.	Of original area.	Of reduced area.	
		Lbs.	*m. s.*	*In.*	*In.*		*In.*	*In.*		*In.*	*In.*		*In.*	*In.*	*In.*		*Lbs.*	*Lbs.*	*Per ct.*
223*	H Wco 4 UNA'D	3,500	2 00	.020	......	.2	.004	......	.04	.016	......	.16	.2991 x .3001	......	......	......	......	......	......
		3,800	2 30	.020	......	.2	......	......	......	......	......	......	......	......	......	......	......	......	......
		4,000	2 00	.023	......	.23	.005	......	.05	.018	......	.18	......	......	......	......	......	......	......
		4,200	2 00	.023	......	.23	.005	......	.05	.018	......	.18	......	......	......	......	......	......	......
		4,500	2 30	.024	......	.24	.005	......	.05	.019	......	.19	......	......	......	......	......	......	......
		5,000	2 30	.026	......	.26	.006	......	.06	.020	......	.20	......	......	......	......	......	......	......
		5,500	2 30	.029	......	.29	.007	......	.07	.022	......	.22	......	......	......	......	......	......	......
		6,000	2 15	.034	......	.34	.008	......	.08	......	......	.26	......	......	......	......	......	......	......
		6,500	3 15	.038	......	.38	.010	......	.1	.028	......	.28	......	......	......	......	......	......	......
		7,000	3 30	.045	......	.45	.015	......	.15	.030	......	.30	......	......	......	......	......	......	......
		7,500	5 00	.050	......	.50	.018	......	.18	.032	......	.32	......	......	......	......	......	......	......
		8,000	6 25	.056	......	.56	.021	......	.21	.035	......	.35	......	......	......	......	......	......	......
		8,500	8 00	.072	......	.72	.030	......	.3	.042	......	.42	......	......	......	......	......	......	......
		9,000	12 00	.098	......	.98	.054	......	.54	.044	......	.44	......	......	......	......	......	......	......
		9,320	1 30	......	......	......	.056	......	.56	......	......	......	......	......	......	......	130,830	......	37.55
		7,000	1 25	Broke;	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
224*	C Hco 4 S UNA'D	3,500	2 30	.014	......	.14	.000	......	......	.014	......	.14	.294 x .296	......	......	......	......	......	......
		3,800	1 30	.017	......	.17	.000	......	......	.017	......	.17	......	......	......	......	......	......	......
		4,000	2 00	.017	......	.17	.000	......	......	.017	......	.17	......	......	......	......	......	......	......
		4,500	2 00	.018	......	.18	.000	......	......	.018	......	.18	......	......	......	......	......	......	......
		5,000	2 00	.020	......	.20	.000	......	......	.020	......	.20	......	......	......	......	......	......	......
		5,500	2 20	.024	......	.24	.000	......	......	.024	......	.24	......	......	......	......	......	......	......
		6,000	1 35	.027	......	.27	.000	......	......	.027	......	.27	......	......	......	......	......	......	......
		6,500	1 30	.029	......	.29	.000	......	......	.029	......	.29	......	......	......	......	......	......	......
		7,000	3 00	.032	......	.32	.000	......	......	.032	......	.32	......	......	......	......	......	......	......

		7,500	2 45	.037	......	.37	.003	......	.03	.034	......	.34	......	......	......	......	......	......	......
		8,000	5 00	.044	......	.44	.007	......	.07	.037	......	.37	......	......	......	......	......	......	......
		8,500	5 15	.050	......	.50	.012	......	.12	.038	......	.38	......	......	......	......	......	......	......
		9,000	10 00	.064	......	.64	.020	......	.2	.044	......	.44	......	......	......	......	......	......	......
		9,300	45	......	......	......	......	......	......	......	......	......	......	......	......	......	106,867	......	78.50
		8,400	1 00	Broke	......	......	.006	......	.06	......	......	......	......	......	.2467 x .247	69.82	......	137,852	......
225*	T co 3 * UNA'D	3,500	1 50	.016	......	.16	.003	......	.03	.013	......	.13	.2997 x .3052	......	......	......	......	......	......
		4,000	1 30	.019	......	.19	.003	......	.03	.016	......	.16	......	......	......	......	......	......	......
		4,500	1 40	.020	......	.20	.003	......	.03	.017	......	.17	......	......	......	......	......	......	......
		5,000	2 00	.022	......	.22	.003	......	.03	.019	......	.19	......	......	......	......	......	......	......
		5,500	1 50	.024	......	.24	.003	......	.03	.021	......	.21	......	......	......	......	......	......	......
		6,000	4 00	.027	......	.27	.003	......	.03	.024	......	.24	......	......	......	......	......	......	......
		6,500	2 20	.031	......	.31	.003	......	.03	.029	......	.28	......	......	......	......	......	......	......
		7,000	2 45	.035	......	.35	.003	......	.03	.022	......	.32	......	......	......	......	......	......	......
		7,500	3 10	.040	......	.40	.006	......	.06	.034	......	.34	......	......	......	......	......	......	......
		8,000	3 00	.045	......	.45	.010	......	.10	.035	......	.35	......	......	......	......	......	......	......
		8,500	6 00	.051	......	.51	.013	......	.13	.048	......	.38	......	......	......	......	......	......	......
		9,000	5 30	.060	......	.60	.018	......	.18	.042	......	.42	......	......	......	......	......	......	......
		9,500	6 20	.075	......	.75	.029	......	.29	.046	......	.46	......	......	......	......	......	......	......
		10,000	3 15	Broke	......	......	.021	......	.21	......	......	......	......	......	.279 x .2915	88.90	108,222	......	35.00
226*	T co 6 * UNA'D	3,500	2 30	.015	......	.15	.000	......	......	.015	......	.15	.3061 x .3013	......	......	......	......	......	......
		4,000	1 40	.017	......	.17	.000	......	......	.017	......	.17	......	......	......	......	......	......	......
		4,500	2 00	.020	......	.20	.000	......	......	.020	......	.20	......	......	......	......	......	......	......
		5,000	2 00	.022	......	.22	.000	......	......	.022	......	.22	......	......	......	......	......	......	......
		5,500	1 30	.024	......	.24	.000	......	......	.024	......	.24	......	......	......	......	......	......	......
		6,000	2 30	.027	......	.27	.000	......	......	.027	......	.27	......	......	......	......	......	......	......
		6,500	2 00	.029	......	.29	.000	......	......	.029	......	.29	......	......	......	......	......	......	......
		7,000	1 40	.032	......	.32	.002	......	.02	.030	......	.30	......	......	......	......	......	......	......
		7,500	1 30	.035	......	.35	.002	......	.02	.033	......	.33	......	......	......	......	......	......	......
		8,000	2 30	.039	......	.39	.003	......	.03	.036	......	.36	......	......	......	......	......	......	......
		8,500	3 00	.040	......	.40	.003	......	.03	.037	......	.37	......	......	......	......	......	......	......
		9,000	3 13	.046	......	.46	.005	......	.05	.041	......	.41	......	......	......	......	......	......	......
		9,500	3 00	.051	......	.51	.006	......	.06	.045	......	.45	......	......	......	......	......	......	......
		10,000	2 30	.056	......	.56	.008	......	.08	.048	......	.48	......	......	......	......	......	......	......
		10,500	2 45	.062	......	.62	.013	......	.13	.049	......	.49	......	......	......	......	......	......	......
		11,000	6 00	.072	......	.72	.018	......	.18	.054	......	.54	......	......	......	......	......	......	......
		11,500	8 00	.086	......	.86	.029	......	.29	.057	......	.57	......	......	......	......	......	......	......
		12,000	9 00	.117	......	1.17	.056	......	.56	.061	......	.61	......	......	......	......	......	......	......
		12,450	1 30	Broke	......	......	.041	......	.41	......	......	......	......	......	......	......	134,990	......	53.82
227†	BS co H D *.....	3,000	2 45	.012	......	.12	.000	......	......	.012	......	.12	.3032 x .2995	......	......	......	......	......	......
		3,500	2 00	.016	......	.16	.000	......	......	.016	......	.16	......	......	......	......	......	......	......
		4,000	2 30	.017	......	.17	.000	......	......	.017	......	.17	......	......	......	......	......	......	......
		4,500	1 20	.018	......	.18	.000	......	......	.018	......	.18	......	......	......	......	......	......	......
		5,000	1 50	.021	......	.21	.000	......	......	.021	......	.21	......	......	......	......	......	......	......

* Drawn from three-eighths inch rod in three draughts; annealed before each. † Drawn three draughts without annealing. ‡ About ⅛-inch within the upper clamp.

TABLE 9.—*TENSILE TESTS of various unannealed gun-wires of different manufacture*—Continued.

Mark on specimen designating—		Strain.		Elongation under strain.			Elongation after release.			Resilience.			Dimensions of cross-section.				Strain per square inch.		Elastic limit of strain compared with highest strain.
No. of experiment.	Material.	On specimen.	Time of application.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	In 10 inches of original length.	In 5 inches of original length.	Percentage of original length.	Original.	Under strain, (smallest place.)	Released, (smallest place.)	Percentage of original area.	Of original area.	Of reduced area.	
		Lbs.	*m. s.*	*In.*	*In.*		*In.*	*In.*		*In.*	*In.*		*In.*	*In.*	*In.*		*Lbs.*	*Lbs.*	*Per ct.*
		5,500	2 05	.023		.23	.000			.023		.23							
		6,000	3 30	.025		.25	.000			.025		.25							
		6,500	3 30	.028		.28	.000			.028		.28							
		7,000	7 00	.035		.35	.006		.06	.029		.29							
		7,500	5 00	.045		.45	.015		.15	.030		.30							
		7,650	0 40														84,386		87.58
		6,250	1 00	Broke			.014		.14										
228*	BS co * UNAN'D	3,000	2 00	.010		.1	.000			.010		.1	.2989 x .305						
		3,500	1 50	.011		.11	.000			.011		.11							
		4,000	2 00	.014		.14	.000			.014		.14							
		4,500	1 30	.015		.15	.000			.015		.15							
		5,000	2 00	.017		.17	.000			.017		.17							
		5,500	4 00	.023		.23	.000			.023		.23							
		6,000	1 50	.025		.25	.000			.025		.25							
		6,500		.035		.35	.008		.08	.035		.35							
		6,775															58,685		91.51
		5,350		Broke			.016		.16										
229*	CH co 5 I UNA'D	2,500	1 39	.012		.12	.000			.012			.292 x .292						
		3,000	1 15	.014		.14	.002		.02	.012		.12							
		3,500	2 00	.016		.16	.003		.03	.013		.13							
		4,000	1 45	.019		.19	.003		.03	.016		.16							
		4,500	2 00	.020		.20	.004		.04	.016		.16							
		5,000	2 00	.024		.24	.005		.05	.019		.19							
		5,500	2 00	.028		.28	.006		.06	.022		.22							
		6,000	5 00	.066		.66	.039		.39	.027		.27							
		6,400	4 00														59,227		40.62
		5,050	1 00	Broke			.394	.125	3.94						.218 x .224	57.27		103,416	

* Drawn three draughts; annealed before each.

TABLE 10.—*TENSILE TESTS of turned specimens of tool-steel ("best cast steel") procured from the agencies of the various manufacturers.*

[For explanation of marks see pages 136 to 140, inclusive.]

Mark on specimen designating—		Strain.		Elongation after release.			Dimensions of cross-section.				Strain per square inch.		Remarks.
No. of experiment.	Material.	On specimen.	Time of application.	In 2 inches of original length.	In 1 inch of original length.	Percentage of original length.	Original—round.	Under strain, (smallest place.)	Released, (smallest place.)	Percentage of original area.	Of original area.	Of reduced area.	
		Lbs.	*m. s.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*		*Lbs.*	*Lbs.*	
230	Jco 1	1,900	5 00				.2565 x .2565				36,767		Began to yield.
		4,125	5 20						.235 x .235	.83938	79,825	95,100	
		3,900	0 30	*.304	.104				†.220 x .220	.73564		102,491	Broke about .40″ below upper mark:
231	J co 2	2,000	3 30				.2526 x .2522				39,970		Began to yield; at 2,100 stretched fast, (comparatively.)
		4,275	5 07						.2287 x .2296	.82425	85,438	103,655	
		3,850	0 50	*.355	.127				†.198 x .198	.61539		125,033	Broke about .40″ below upper mark.
232	S B co 1	1,900	4 00				.252 x .2521				38,077		Began to yield; at 2,200 stretched fast.
		4,700	4 50						.2331 x .2331	.69787	94,192	100,130	
		4,440	0 25	*.198	.057				†.216 x .216	.73421		131,162	Broke about .20″ below upper mark.
233	S B co 2	1,800	4 00				.2523 x .2529				35,835		Began to yield; at 2,100 stretched faster.
		4,700	3 20						.2355 x .236	.87247	93,617	107,643	
		4,325	0 25	*.231	.067				†.218 x .218	.74333		115,868	Broke about .25″ below upper mark.
245	H E co 1	2,200	4 00				.2503 x .2503				44,710		Began to yield.
		5,210	5 00						.235 x .2351	.88185	105,880	120,070	
		5,125	0 15	*.202	.084				†.2305 x .2305	.84804		122,819	Broke about .30″ below upper mark.
246	H E co 2	2,800	6 00				.2521 x .2522				56,084		Began to yield.
		5,390	3 25						.2395 x .240	.10611	107,961	119,348	
		5,100	0 20	*.221	.090				†.224 x .224	.78919		129,415	Broke about .45″ above lower mark.
247	N co T 1	2,700	7 00				.2515 x .2546				59,784		Began to yield; faster at 2,850 lbs.
		5,670	2 18	*.099	.045				†.246 x .246	.93396		119,295	Broke suddenly upon reaching strain 5,670 lbs., parting about .25″ below upper mark.

* Measured after putting together the parts, allowance being made for imperfect contact.

† Fractured.

TABLE 10.—*TENSILE TESTS of turned specimens of tool-steel, &c.*—Continued.

Mark on specimen designating—		Strain.		Elongation after release.			Dimensions of cross-section.				Strain per square inch.		Remarks.
No. of experiment.	Material.	On specimen.	Time of application.	In 2 inches of original length.	In 1 inch of original length.	Percentage of original length.	Original—round.	Under strain, (smallest place.)	Released, (smallest place.)	Percentage of original area.	Of original area.	Of reduced area.	
		Lbs.	*m. s.*	*In.*	*In.*		*In.*	*In.*	*In.*		*Lbs.*	*Lbs.*	
248	N co T 2	2,200	4 00				.2495 x .2496				44,924		Began to yield; faster at 2,500 lbs.
		4,925	3 25						.231 x .231	.85686	100,560	117,516	
		4,700	0 43	†.190	.050				‡.2173 x .2172	.75788		126,793	Broke about .30″ below upper mark.
249	H W co T	2,500	4 00				.252 x .252				50,125		Began to yield; faster at 2,800 lbs.
		6,325	3 27						.2355 x .2355	.87333	126,817	145,187	
		6,075	0 30	†.174	.057				‡.226 x .226	.80429		151,443	Broke about ¼″ below upper mark.
250	J B H co	1,800	2 00				.2516 x .2515				36,234		Began to yield; faster at 2,200 lbs.
		4,800	5 40	†.254	.121				‡.227 x .227	.81434	96,624	118,660	
												118,660	Broke about .30″ above lower mark, suddenly; coarse-grained; flaw in center.
251	E M co 2	2,200	3 00				.2525 x .2524				43,934		Began to yield; faster at 2,300 lbs.
		4,445	4 50						.233 x .232	.84952	88,768	104,701	
		4,000	0 39	†.298	.117				‡.225 x .227	.80293		98,821	Broke about .30″ above lower mark.
252	E M co 1	2,400	5 00				.2511 x .2512				48,273		Began to yield; took quite a stretch at 2,500 lbs.
		4,510	4 00						.2302 x .2305	.84122	90,713	108,270	
		3,900	1 05	†.357	.140				‡.1938 x .1938	.59544		131,936	Broke.

† Measured after putting together the parts, allowance being made for imperfect contact.

‡ Fractured.

TABLE 11.—*Experiments on square compound wires of welded iron and steel.*

[See page 140 and Plate 4, Figures 7 and 8.]

Date.	Mark on specimen designating—		Original dimensions of cross-section.	Tensile strain.		Strain per square inch.	Elongation under strain.		Elongation after release.		Resilience.		Spontaneous contraction—		Remarks.
	No. of experiment.	Material.		On specimen.	Time of application.	Of original area.	In 5 inches of original length.	Percentage of original length.	In 5 inches of original length.	Percentage of original length.	In 5 inches of original length.	Percentage of original length.	In 5 inches.	Percentage.	
			Inches.	*Lbs.*	*m. s.*	*Lbs.*	*In.*		*In.*		*In.*				
1874. May 1	168	T & S 1 C	.2922 x .2927	1,000	......	......	.005	.10	.000	......	.005	.10	......	......	These experiments were made with reference to the accommodation of conflicting strains by their own prolonged action. After being subjected to the strains mentioned, the specimens were laid aside until the date of the last measurement. Great care was taken in the measurements, the calipers having been set to the same standard in each instance.
				3,000	1 50		.014	.28	.006	.12	.009	.16	......	......	
				3,000	4 00		.064	1.28	......	......	.064	1.28	......	......	
				3,000	1 00		......	......	.056	1.12	......	......	......	......	
				4,000	1 27		.129	2.58	.117	2.34	.012	.24	......	......	
				4,000	5 00	46,768	.132	2.64	.124	2.48	.008	.16	......	......	
1875. Oct. 12				0	......		......	......	.118	......	......	......	.006	.12	
1874. May 1	169	T & S 8 C	.2898 x .2898	1,000	2 00		.002	.04	.000	......	.002	.04	......	......	
				3,000	1 30		.007	.14	.003	.06	.004	.08	......	......	
				3,000	10 30		.020	.40	.012	.24	.008	.16	......	......	
				4,000	1 50		.110	2.20	.101	2.02	.009	.18	......	......	
				4,000	6 00		.118	2.36	.107	2.14	.011	.22	......	......	
				5,000	2 30		.216	4.32	.202	4.04	.014	.28	......	......	
				5,000	7 00	59,642	.234	4.68	.221	4.41	.013	.27	......	......	
1875. Oct. 12				0	......		......	......	.219	......	......	......	.002	.04	

TABLE 12.—*Experiment on changes of dimensions by annealing.*

Square gun-wires.	Before annealing.		After annealing.	
Mark designating kind of material.	Measurements.		Measurements.	
	Of length.	Of cross-section.	Of length.	Of cross-section.
	Inches.	*Inches.*	*Inches.*	*Inches.*
B A	12	.3028 x .3028	12.006	.3028 x .3064*
B D	12	.302 x .305	12.004	.3020 x .3050
B F	12	.3022 x .3046	12.001	.3020 x .3036
B J	12	.305 x .3056	12.000	.3046 x .3055
B M	12	.305 x .3028	12.001	.3052 x .3029
B P	12	.3018 x .3034	12.001	.3017 x .3033
B R	12	.3037 x .3038	12.004	.3029 x .3039
B T	12	.3022 x .3040	12.000	.3029 x .3045
B U	12	.3020 x .3017	12.000	.3019 x .3018
B W	12	.3031 x .3033	12.000	.3027 x .3028
B Y	12	.3050 x .3032	12.004	.3057 x .3033
B Z	12	.3023 x .3031	12.004	.3023 x .3030
C A	12	.3022 x .3021	12.000	.3029 x .3021
C C	12	.3038 x .3035	12.000	.3042 x .3035
C B	12	.3045 x .3044	12.000	.3045 x .3050

* So large a variation ($\frac{36}{10000}$ of an inch) suggests some change of form—perhaps the slight opening of the wire from an internal defect.

TORSIONAL TESTS.

REDUCTION OF STRAINS.

The figures given in the tables, under the heading "*Strain reduced to correspond to cross-section of* 0''.3 x 0''.3," are derived from comparisons based upon the assumption that with the same material, in the same condition, resistance to torsion, in cylinders and prisms, is in proportion to the cubes of the corresponding dimensions of their cross-sections.

Confirmation of this rule may be found in Tables 18–24.

SEAMS.

Some of the specimens, as noted under the head of "*Remarks*," were found to have one or more seams, This was of frequent occurrence with specimens drawn from "sprues."

In order that some idea of the extent to which these defects affected the resistance and extent of torsion of the specimens in which they occurred, a few experiments were made upon wires purposely prepared to exhibit this defect in a known degree.

Two rods of steel, 0''.4 square, one of them of the kind indicated by the letters **B Sco 2**, and the other by **M co 3**, the former a very *low* steel, and the latter above the average of the faulty wires in carburization, were selected for the purpose. In the center of each side of these rods a groove was planed longitudinally, designed to have a width of 0''.05 and depth of 0''.12, and differing but little from those measurements. The form of cross-section thus produced is given in figure 5 of plate 4. These rods were annealed and drawn into wire in the usual way, by which the grooves were closed, seams being left, however, in the situations indicated by the lines on the section Fig. 6 of the same plate. Specimens of these wires were tested, both by torsional and tensile strains. The primary record, however, appears not to have been regularly entered, and is (the only one so far as known) lost. Speaking from recollection, the general results were as follows:

Under tensile tests no marked variation was found from the results with solid wires.

Under torsional strains, compared with solid wires, **B Sco 2** gave considerably more torsion at low strains, and *ultimate torsion* was likewise in small excess. **M co 3** also gave more torsion under the lighter strains, but the ultimate torsion fell short decidedly. Both specimens gave less resistance, but it is believed that the diminution was in both cases less (perhaps considerably so) than 25 per cent.

Simple inspection of the wires after breaking was found to afford very little indication of the depth of seams: they were almost universally undiscoverable before twisting. An expedient was adopted to give better indication. Across each side of the specimen a fine line was drawn at right angles with its corners. If the specimen was sound, these lines remained continuous, but otherwise if there was a seam. In the latter case the line was divided at the place of the seam, and the parts separated to an extent depending on its depth. This result is intended to be illustrated in plate 4, Fig. 4. Figure 3 of the same plate shows the continuous line.

The space between the separated ends of the cross-lines, if considerable, is noted in the "*Remarks*" following the mention of "a seam."

PLACE OF FRACTURE.

The place of fracture in the specimens is generally not given in the tables. In nearly all cases it was at one end or the other, as represented in Figs. 2 and 3, plate 4. The exceptions were in the case of some specially hard steels, which broke in a manner designed to be illustrated in Fig. 1 of the same plate.

EXTENT OF TORSION.

The length of the specimens, between the clamps or between their shoulders, was generally one inch, and is so stated in the tables. It may be well to remark here, however, that the torsion occurring in these specimens is greater than the torsion per inch of longer ones of the same kind. This results from some yielding of the metal outside of the inch measured, which is inseparable from the torsion of the measured part. The relative results are not supposed to be materially affected thereby.

TABLE 13.—*TORSIONAL TESTS.—Comparison of results of annealing at different temperatures.*

Mark on specimen designating— Experiment number.	Mark on specimen designating— Material.	Time of twisting.	Strain applied, (one foot from center.)	Torsion. Under strain, (first detected yielding.)	Torsion. Released.	Resilience.	Highest strain.	Ultimate torsion.	Highest strain reduced to correspond to cross-section of 0″.3 x 0″.3.	Measurement of cross-section of wires.	Remarks.
		m. s.	*Lbs.*	*Turns.*	*Turns.*	*Turns.*	*Lbs.*	*Turns.*	*Lbs.*	*Inches.*	
21	O.............	6 30	13.92	0.008	0.003	0.005	41.02	1.02	40.11+	.302 x .301	The first of each pair of specimens in this table was annealed at the temperature adopted as a standard, viz: that between the melting-points of bronze and copper. The second of each pair was annealed at a heat which melted copper.
22	O.............	6 00	12.52	0.006	0.002	0.004	40.55	0.805	39.95+	.302 x .301	
23	D.............	6 15	13.33	0.007	0.003	0.004	40.66	0.859	39.58+	.302 x .303	
24	D.............	6 00	12.34	0.006	0.002	0.004	39.97	0.925	38.98+	.302 x .303	
25	H.............	6 30	13.95	0.01	0.004	0.006	41.96	0.875	40.72+	.301 x .305	
26	H.............	8 00	13.14	0.007	0.003	0.004	40.95	0.83	39.74+	.301 x .305	
27	J.............	7 30	14.16	0.007	0.003	0.004	43.24	0.95	42.22+	.302 x .305	
28	J.............	5 30	13.59	0.007	0.003	0.004	42.56	0.935	41.55+	.302 x .305	
29	U.............	7 00	14.87	0.007	0.003	0.004	42.44	0.896	40.80+	.303 x .305	
30	U.............	6 00	12.62	0.006	0.002	0.004	41.39	0.935	39.79+	.303 x .305	
31	L.............	6 30	14.43	0.008	0.004	0.004	43.31	0.884	42.03+	.302 x .304	
32	L.............	7 30	12.70	0.007	0.002	0.005	41.75	0.779	40.52	.302 x .304	
33	C.............	9 45	15.38	0.009	0.003	0.006	50.59	0.793	53.62	.296 x .294	
34	C.............	7 30	15.47	0.009	0.003	0.006	50.43	0.753	53.45	.296 x .294	
37	I.............	6 45	13.89	0.009	0.005	0.004	41.83	0.972	40.59	.303 x .303	
38	I.............	8 30	13.21	0.008	0.003	0.005	40.69	1.045	37.77	.303 x .303	
39	X.............	7 30	13.93	0.009	0.005	0.004	42.00	0.931	40.56	.303 x .304	
40	X.............	8 15	12.84	0.006	0.003	0.003	41.07	0.906	39.70	.303 x .304	
41	T.............	7 30	15.37	0.007	0.003	0.004	44.62	0.891	43.09	.303 x .304	
42	T.............	7 45	14.31	0.009	0.005	0.004	43.32	0.8	41.84	.303 x .304	

43	A G	8 00	14. 31	0. 008	0. 004	0. 004	41. 68	1. 03	41. 06	. 301 x . 302
44	A G	7 00	13. 23	0. 007	0. 003	0. 004	41. 22	1. 024	40. 60	. 301 x . 302
45	A N	7 30	14. 35	0. 007	0. 002	0. 005	43. 71	0. 856	41. 59	. 305 x . 305
46	A N	7 45	13. 65	0. 008	0. 003	0. 005	42. 68	0. 79	40. 61	. 305 x . 305
47	A M	7 00	13. 54	0. 01	0. 005	0. 005	41. 20	0. 854	41. 61	. 299 x . 299
48	A M	6 45	12. 72	0. 007	0. 003	0. 004	40. 60	1. 000	41. 01	. 299 x . 299
49	A J	8 00	14. 54	0. 008	0. 003	0. 005	41. 83	0. 947	39. 80	. 304 x . 306
50	A J	7 00	12. 38	0. 006	0. 003	0. 003	40. 79	0. 876	38. 81	. 304 x . 306
51	A E	5 00	13. 88	0. 007	0. 003	0. 004	40. 77	0. 95	39. 18	. 303 x . 305
52	A E	8 30	12. 65	0. 006	0. 003	0. 003	40. 24	0. 971	38. 64	. 303 x . 305
53	A P	6 15	13. 49	0. 007	0. 004	0. 003	41. 68	0. 95	40. 65	. 302 x . 303
54	A P	7 15	12. 80	0. 006	0. 002	0. 004	40. 51	0. 946	39. 51	. 302 x . 303

TABLE 14.—*TORSIONAL TESTS.—Comparison of wires of Martin steel, the product of two different charges.*

Mark on specimen designating—		Measurements of cross-section of wire.	Strain applied 1 foot from center.	Torsion.		Resilience.	Highest strain.	Ultimate torsion in length of wire.	Highest strain reduced to correspond to cross-section of 0″.3 x 0″.3.	Time of twisting.	Remarks.
No. of experiment.	Material.			Under strain.	Released.						
		Inches.	*Lbs.*	*Turns.*	*Turns.*	*Lbs.*	*Lbs.*	*In.*	*Lbs.*	*m. s.*	
55	C H co 4 S [F]	0. 296 x 0. 294	15. 28	0. 010	0. 003	. 007	49. 50	0. 724	51. 67	7 00	The specimens marked C H co 4 S, with another letter in brackets, were annealed in contact with the specimens marked with the last letter only. This was done that none of the differences in quality should be attributable to differences in the temperature to which the specimens were exposed in annealing. Apparently a slight seam extends the whole length of the pieces marked C H co 4. The other pieces appear to be perfectly sound. They are from a sample of 1,000 pounds, intended to have been of the same quality with C H co 4 S.
56	F	0. 305 x 0. 3035	14. 47	0. 007	0. 002	. 005	42. 74	0. 954	40. 97	8 00	
57	C H co 4 S [N]	0. 2945 x 0. 2934	15. 31	0. 009	0. 004	. 005	49. 99	0. 757	53. 14	8 00	
58	N	0. 3028 x 0. 3033	14. 48	0. 008	0. 003	. 005	43. 31	0. 975	42. 01	5 30	
59	C H co 4 S [W]	0. 2945 x 0. 296	15. 26	0. 010	0. 003	. 007	50. 76	0. 750	54. 58	7 30	
60	W	0. 304 x 0. 304	15. 09	0. 007	0. 002	. 005	43. 67	0. 895	41. 97	5 45	
61	C H co 4 S [P]	0. 293 x 0. 2945	15. 34	0. 009	0. 003	. 006	50. 31	0. 775	53. 58	7 45	
66	P	0. 299 x 0. 300	13. 92	0. 007	0. 002	. 005	40. 96	1. 076	41. 16	6 00	
64	C H co 4 S [Z]	0. 2945 x 0. 2962	14. 40	0. 008	0. 003	. 005	50. 07	0. 747	52. 47	7 30	
65	Z	0. 3044 x 0. 303	13. 90	0. 007	0. 002	. 005	43. 75	1. 022	42. 17	5 00	

TABLE 15.—*TORSIONAL TESTS of gun-wires of various manufacture.*

[For explanation of marks see pages 136 to 140, inclusive.]

Mark on specimen designating—		Strain at first detected yielding—applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Breaking-strain.	Ultimate torsion.	Highest strain reduced to correspond to cross-section of 0″.3 x 0″.3.	Measurement of cross-section of wire.	Remarks.
No. of experiment.	Material.		Under strain.	Released.							
		Pounds.	*Turns.*	*Turns.*	*Turns.*	*m.*	*Pounds.*	*Turns.*	*Pounds.*	*Inches.*	
189	Nco I	8.26	0.006	0.002	.004	5½	30.51	1.097	33.15	0.2912 x 0.2922	All the specimens referred to in this table were annealed at a temperature between the melting points of bronze and copper, without oxidation of surface.
190	Nco I :	8.38	0.007	0.002	.005	5¼	30.98	1.135	33.30	0.2918 x 0.2933	
191	P Bco 1	Lost ..	Lost ..	Lost ..	....	6¼	32.33	0.852	33.62	0.2970 x 0.2952	
192	P Bco 1 :	8.54	0.006	0.002	.004	4¾	31.73	0.843	33.03	0.2962 x 0.2958	
193	P Bco 2	13.20	0.007	0.002	.005	8	44.58	0.990	43.80	0.3025 x 0.3010	
194	P Bco 2 :	13.26	0.008	0.003	.005	5¾	44.49	0.983	43.96	0.3030 x 0.3010	
195	P Bco 3	13.70	0.009	0.004	.005	7	43.98	0.970	44.80	0.2955 x 0.3008	
196	P Bco 3 :	13.22	0.008	0.002	.006	5½	44.47	0.940	44.34	0.2990 x 0.3015	
197	P Bco 4 cc	13.25	0.008	0.003	.005	7	44.81	0.717	45.60	0.2975 x 0.2990	
198	P Bco 4 cc :	13.23	0.008	0.002	.006	6½	44.95	0.730	44.95	0.2975 x 0.2990	
199	C Sco 5	16.53	0.008	0.002	.006	8	50.08	0.587	50.08	0.2937 x 0.2967	
200	C Sco 5 :	16.48	0.008	0.003	.005	7½	51.00	0.591	51.00	0.2936 x 0.2970	
201	C Sco 6	14.88	0.007	0.002	.005	7	46.22	0.737	49.80	0.2920 x 0.2955	
202	C Sco 6 :	14.81	0.007	0.002	.005	7½	45.99	0.719	48.63	0.2929 x 0.2960	
203	C Sco 7	13.10	0.007	0.002	.005	6½	40.47	0.929	43.21	0.2912 x 0.2958	

TABLE 15.—*TORSIONAL TESTS of gun-wires of various manufacture*—Continued.

Mark on specimen designating—		Strain at first detected yielding—applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Breaking-strain.	Ultimate torsion.	Highest strain reduced to correspond to cross-section of 0″.3 x 0″.3.	Measurement of cross-section of wire.	Remarks.
No. of experiment.	Material.		Under strain.	Released.							
		Pounds.	*Turns.*	*Turns.*	*Turns.*	*m.*	*Pounds.*	*Turns.*	*Pounds.*	*Inches.*	
204	C Sco 7 :	13.29	0.007	0.002	.005	7	40.35	0.911	41.98	0.2969 x 0.2952	
205	C Sco 8	14.91	0.008	0.003	.005	6½	49.51	0.712	52.06	0.2935 x 0.2965	
206	C Sco 8 :	15.20	0.008	0.003	.005	7¼	48.93	0.688	52.27	0.2932 x 0.2962	
207	C Hco 1 S......	15.36	0.008	0.002	.006	6	43.91	0.989	45.83	0.2960 x 0.2954	
208	C Hco 1 S : ...	14.94	0.007	0.002	.005	7½	43.88	0.968	45.78	0.2950 x 0.2965	
209	C Hco 2 S......	13.50	0.007	0.002	.005	6	41.50	1.003	44.31	0.2926 x 0.2927	
210	C Hco 2 S :	13.00	0.006	0.001	.005	6	41.06	0.986	44.22	0.2925 x 0.2927	
211	C Hco 3 S......	12.82	0.006	0.001	.005	6½	41.38	1.009	43.43	0.2941 x 0.2963	
212	C Hco 3 S :	13.46	0.007	0.002	.005	4½	41.57	1.091	43.91	0.2931 x 0.2960	
213	C Hco 5 I	9.52	0.005	0.002	.003	4¾	31.63	1.018	34.19	0.2928 x 0.2921	
214	C Hco 5 I :	9.65	0.007	0.002	.005	5¾	31.61	1.049	34.26	0.2921 x 0.2920	
215	H Wco 4	17.23	0.009	0.003	.006	8	57.58	0.736	57.86	0.3000 x 0.2990	
216	H Wco 4 :	17.10	0.009	0.003	.006	7¼	57.25	0.724	57.39	0.2997 x 0.2997	
217	H Wco 5.......	12.20	0.005	0.003	.002	4	35.40	1.098	35.93	0.2970 x 0.3000	
218	H Wco 5 :	12.00	0.006	0.003	.003	4¼	35.18	1.083	35.39	0.2988 x 0.3000	
219	H Wco 6.......	12.13	0.006	0.003	.003	5	35.80	0.946	36.17	0.2984 x 0.2995	

220	H Wco 6:......	12.15	0.006	0.003	.003	4½	36.19	0.949	36.68	0.2983 x 0.2990
221	H Wco 7.......	12.58	0.007	0.002	.005	4¾	42.97	0.764	42.97	0.3010 x 0.2990
222	H Wco 7:......	13.42	0.007	0.001	.008	5½	43.35	0.800	43.34	0.3009 x 0.2994
223	C A............	12.29	0.008	0.003	.005	6½	46.84	0.954	46.76	0.3015 x 0.3015
224	C B............	17.27	0.010	0.003	.007	5¾	59.79	0.628	56.75	0.3058 x 0.3047
225	C C............	14.39	0.008	0.002	.006	5½	51.77	0.821	49.94	0.3033 x 0.3039
226	C D............	13.28	0.007	0.002	.005	5	50.21	0.747	49.14	0.3020 x 0.3023
227	C E............	14.11	0.009	0.004	.005	5½	50.43	0.809	48.78	0.3030 x 0.3044
228	B A............	15.34	0.008	0.003	.005	6	55.52	0.726	54.42	0.3028 x 0.3012
229	B B............	15.35	0.008	0.003	.005	5½	53.87	0.761	53.05	0.3018 x 0.3020
230	B C............	12.20	0.007	0.003	.004	5	44.45	0.831	43.52	0.3022 x 0.3020
231	B D............	18.48	0.009	0.003	.006	5¼	61.30	0.589	58.90	0.3035 x 0.3045
232	B E............	17.35	0.009	0.002	.007	7	60.82	0.668	56.89	0.3038 x 0.3020
233	B F............	11.74	0.005	0.002	.003	4¾	45.41	0.906	44.44	0.3015 x 0.3028
234	B G............	13.72	0.006	0.002	.004	6	52.00	0.787	50.22	0.3035 x 0.3035
235	B H............	14.50	0.007	0.002	.005	6	53.46	0.700	52.65	0.3013 x 0.3015
236	B I............	13.79	0.007	0.003	.004	5⅝	51.86	0.807	50.13	0.3040 x 0.3028
237	B J............	15.20	0.009	0.003	.006	6¼	54.48	0.784	53.61	0.3018 x 0.3015
238	B K............	16.16	0.008	0.003	.005	6	56.00	0.693	54.80	0.3016 x 0.3027
239	B L............	15.26	0.009	0.004	.005	6¼	54.85	0.732	53.56	0.3020 x 0.3027
240	B M...........	20.74	0.010	0.003	.007	7¼	63.79	0.658	61.76	0.3035 x 0.3030
241	B N............	15.41	0.009	0.003	:006	7¾	56.45	0.757	55.66	0.3018 x 0.3010
242	B O............	15.51	0.008	0.003	.005	7½	56.41	0.692	54.85	0.3036 x 0.3021
243	B P............	14.44	0.009	0.003	.006	5¾	50.00	0.857	48.69	0.3035 x 0.3018
244	B Q............	15.58	0.009	0.003	.006	7¼	55.00	0.718	53.91	0.3024 x 0.3016
45	B R............	14.82	0.008	0.003	.005	6¼	53.31	0.793	51.78	0.3031 x 0.3028

TABLE 15.—*TORSIONAL TESTS of gun-wires of various manufacture*—Continued.

Mark on specimen designating—		Strain at first detected yielding, applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Breaking strain.	Ultimate torsion.	Highest strain reduced to correspond to cross-section of 0″.3 x 0″.3.	Measurement of cross-section of wire.	Remarks.
No. of experiment.	Material.		Under strain.	Released.							
		Pounds.	*Turns.*	*Turns.*	*Turns.*	*m.*	*Pounds.*	*Turns.*	*Pounds.*	*Inches.*	
246	B S	14.87	0.007	0.003	.004	6½	54.30	0.706	52.58	0.3035 x 0.3030	
247	B T	18.52	0.011	0.006	.005	5½	52.75	0.780	51.93	0.3010 x 0.3021	
248	B U	18.30	0.010	0.004	.006	6	58.78	0.587	57.89	0.3008 x 0.3020	
249	B V	15.29	0.008	0.003	.005	6	54.95	0.671	53.95	0.3005 x 0.3010	
250	B W	14.50	0.007	0.002	.005	7½	55.00	0.725	55.50	0.3020 x 0.3035	
251	B X	13.28	0.009	0.004	.005	5	51.66	0.833	50.43	0.3035 x 0.3035	
252	B Y	19.16	0.011	0.003	.008	6½	62.00	0.555	61.01	0.3018 x 0.3015	
253	B Z	13.73	0.007	0.002	.005	7	52.54	0.794	51.41	0.3015 x 0.3027	
254	C Hco 4 s	16.39	0.009	0.003	0.006	5¼	51.94	0.810	54.78	0.2933 x 0.2955	
255	Nco 1 s (A)	14.41	0.008	0.003	0.005	6	48.95	0.666	48.74	0.3006 x 0.3002	
256	Nco 1 s (B).....	12.53	0.005	0.007	0.004	5	46.21	0.778	45.88	0.3010 x 0.3004	
257	Nco 1 s (C)....	14.76	0.007	0.002	0.005	5½	50.95	0.714	49.86	0.3020 x 0.3023	
258	Nco 1 s (D)	11.75	0.007	0.002	0.005	5	46.00	0.740	45.31	0.3013 x 0.3015	
259	Nco 1 s (E) ...	13.23	0.007	0.002	0.005	6¼	47.00	0.728	45.54	0.3023 x 0.3040	
260	Nco 1 s (F)....	14.47	0.007	0.003	0.004	6	49.51	0.729	48.04	0.3040 x 0.3020	

TABLE 16.—*TORSIONAL TESTS of gun-wires drawn from Martin steel, made by the New Jersey Steel and Iron Company.*

Mark on specimen designating—		Length of wire.	Strain—applied 1 foot from center.	Torsion.		Resilience in length of wire.	Highest strain.	Ultimate torsion in length of wire.	Strain reduced to correspond to cross-section of 0″.3 x 0″.3.	Time of twisting.	Measurements of cross-section of wire.	Original mark on rods.	Remarks.
No. of experiment.	Material.			Under strain.	Released.								
		In.	*Lbs.*	*Turns.*	*Turns.*	*Turns.*	*Lbs.*	*Turns.*	*Lbs.*	*m. s.*	*In.*		
271	C F	1	13.81	0.007	0.001	0.006	......	......	16.14	......	.2980 x .2988	1 C 1 G T	The wires of each of the four sets of specimens (C F to C L) mentioned in this table were annealed at the same time, closely bound in the same bundle, all at a heat between the melting points of bronze and copper.
271	C F	1	14.94	0.009	0.002	0.007	......	......	17.46	......	......	......	
271	C F	1	15.71	0.010	0.0035	0.0065	......	......	18.36	......	......	......	
271	C F	1	16.34	0.011	0.007	0.004	......	......	19.10	......	......	......	
							47.24	0.860	55.23	4 22	......	......	
272	C G	1	13.62	0.007	0.002	0.005	......	......	13.81	......	.2983 x .2988	1 C 2 G	
272	C G	1	14.28	0.008	0.003	0.005	......	......	14.48	......	......	......	
272	C G	1	15.14	0.012	0.008	0.004	......	......	15.36	......	......	......	
							43.94	0.973	44.58	4 12	......	......	
273	C H	1	15.19	0.009	0.003	0.006	......	......	16.17	......	.2970 x .2983	2 C 1 G	
273	C H	1	16.00	0.014	0.009	0.005	......	......	17.04	......	......	......	
							47.07	0.857	50.12	6 16	......	......	
274	C I	1	14.18	0.007	0.002	0.005	......	......	14.37	......	.2980 x .2986	2 C 2 G	
274	C I	1	15.27	0.009	0.004	0.005	......	......	15.47	......	......	......	
274	C I	1	16.00	0.011	0.007	0.004	......	......	16.21	......	......	......	
							46.88	0.903	47.50	5 48	......	......	
275	C J	1	15.18	0.008	0.003	0.005	......	......	15.38	......	.2993 x .2980	3 C 1 G	
275	C J	1	16.00	0.009	0.004	0.005	......	......	16.21	......	......	......	
275	C J	1	16.56	0.015	0.010	0.005	......	......	16.88	......	......	......	
							47.85	0.946	48.50	4 47	......	......	
276	C K	1	17.54	0.009	0.003	0.006	......	......	17.80	......	......	3 C 2 G	
276	C K	1	18.40	0.010	0.004	0.006	......	......	18.67	......	......	......	
276	C K	1	19.21	0.014	0.008	0.006	......	......	19.50	......	0.298 x .299	......	
							55.94	0.784	56.78	5 30	......	......	
277	C F	1	14.96	0.008	0.002	0.006	......	......	17.49	......	......	......	
			15.53	0.009	0.003	0.006	......	......	18.15	......	......	......	
			16.23	0.011	0.006	0.005	......	......	18.97	......	0.2980 x 0.2988	......	
							47.47	0.854	55.50	4 35	......	......	

TABLE 16.—*TORSIONAL TESTS of gun-wires drawn from Martin steel, made by the New Jersey Steel and Iron Company*—Continued.

Mark on specimen designating—		Length of wire.	Strain—applied 1 foot from center.	Torsion.		Resilience in length of wire.	Highest strain.	Ultimate torsion in length of wire.	Strain reduced to correspond to cross-section of 0″.3 x 0″.3.	Time of twisting.	Measure of cross-section of wire.	Original mark on rods.	Remarks.
No. of experiment.	Material.			Turns.	Released.								
		In.	*Lbs.*	*Turns.*	*Turns.*	*Turns.*	*Lbs.*	*Turns.*	*Lbs.*	*m. s.*	*In.*		
278	C G	1	13.80	0.007	0.002	0.005	......	......	14.00	......	....	....	
			14.46	0.008	0.004	0.004	......	......	14.67	......	....	....	
			14.91	0.011	0.007	0.004	......	......	15.12	......	0.2983 x 0.298	....	
							43.67	0.884	44.30	4 37	....	....	
279	C H	1	14.69	0.007	0.003	0.004	......	......	15.64	......	....	....	
			15.63	0.010	0 006	0.004	......	......	16.64	......	0.2970 x 0.2983	....	
							46.24	0.919	49.24	4 38	....	....	
280	C I	1	15.14	0.009	0.004	0.005	......	......	15.34	......	....	....	
			16.00	0.015	0.010	0.005	......	......	16.21	......	0.2980 x 0.298	....	
							47.12	0.873	47.75	4 40	....	....	
281	C J	1	15.23	0.009	0.003	0.006	......	......	15.43	......	....	....	
			15.95	0.010	0.006	0.004	......	......	16.16	......	....	....	
			16.39	0.010	0.011	0.005	......	......	16.61	......	0.2993 x 0.298	....	
							47.75	0.924	48.39	4 50	....	....	
282	C K	1	16.36	0.008	0.002	0.006	......	......	16.63	......	....	....	
			17.41	0.009	0.003	0.006	......	......	17.70	......	....	....	
			18.22	0.011	0.006	0.005	......	......	18.52	......	0.2978 x 0.299	....	
							53.74	0.790	54.64	6.39	....	....	
283	C F	1	14.50	0.007	0.002	0.005	......	......	14.69	......	....	....	
			15.70	0.009	0.003	0.006	......	......	15.91	......	....	....	
			16.63	0.011	0.006	0.005	......	......	16.85	......	0.2988 x 0.297	....	
							48.37	0.874	49.01	5.35	....	....	
289	C F...	1	18.00	0.06	0.0515	.0085	......	......	18.30	......	.2980 x .2988	....	
							48.39	0.802	49.20	......	....	....	
290	C G...	1	12.00	0.0065	0.001	.0055	......	......	12.17	......	.2983 x .2988	....	
			13.00	0.0085	0.0025	.0060	......	......	13.18	......	....	....	
			14.00	0.010	0.004	.006	......	......	14.20	......	....	....	
			15.00	0.032	0.026	.006	......	......	15.21	......	....	....	
							43.70	0.99	44.33	4.48	....	....	

291	C H..	1	12.00	0.007	0.002	.005			12.78		.2970 x .2983	
			13.00	0.008	0.002	.006			13.84			
			14.00	0.009	0.003	.006			14.91			
			15.00	0.015	0.003	.007			15.97			
			16.00	0.023	0.018	.005			17.04			
							47.68	0.897	50.77	4.00		
292	C I...	1	12.00	0.006	0.001	.005			12.16		.2980 x .2986	
			13.00	0.007	0.0015	.0055			13.17			
			14.00	0.008	0.002	.006			14.18			
			15.00	0.010	0.005	.005			15.20			
			16.00	0.024	0.018	.006			16.21			
							46.67	0.856	47.29	3.55		
293	C J...	1	12.00	0.0065	0.001	.0055			12.16		.2993 x .2980	
			13.00	0.007	0.0014	.0056			13.17			
			14.00	0.0075	0.0015	.0060			14.19			
			15.00	0.008	0.002	.006			15.20			
			16.00	0.010	0.003	.007			16.21			
			17.00	0.014	0.008	.006			17.23			
			18.00	0.025	0.019	.006			18.24			
							50.62	0.840	51.30	4.30		
294	C K...	1	12.00	0.0065	0.001	.0055			12.20		.2978 x .2990	
			13.00	0.007	0.0012	.0058			13.21			
			14.00	0.0075	0.0014	.0061			14.23			
			15.00	0.008	0.0015	.0065			15.25			
			16.00	0.009	0.002	.007			16.27			
			17.00	0.009	0.0022	.0068			17.28			
			18.00	0.010	0.003	.007			18.30			
			19.00	0.014	0.0065	.0075			19.32			
			20.00	0.020	0.012	.008			20.33			
							55.67	0.786	56.61	4.05		
295	C L...	1	12.00	0.0065	0.001	.0055			12.15		.2978 x .2989		This specimen was sent from the works under the supposition that it was a part of the lower portion of the same ingot as that from which specimen C F was taken.
			13.00	0.008	0.003	.005			13.16			
			14.00	0.0315	0.027	.0045			14.18			
					1.180		40.93	1.180	41.46	4.20		
296	C F...	1	12.00	0.007	0.001	.006			12.20		.2980 x .2988	
			13.00	0.0075	0.002	.0055			13.21			
			14.00	0.008	0.0024	.0056			14.23			
			15.00	0.010	0.004	.006			15.25			
			16.00	0.0145	0.010	.0055			16.27			
							47.43	0.830	48.23	3.56		
297	C G...	1	12.00	0.0065	0.0015	.005			12.17		.2983 x .2988	
			13.00	0.0072	0.002	.0072			13.18			
			14.00	0.009	0.005	.004			14.20			
			15.00	0.030	0.025	.005			15.21			
							43.75	0.982	44.38	4.10		

TABLE 16.—*TORSIONAL TESTS of gun-wires drawn from Martin steel, &c.*—Continued.

Mark on specimen designating—		Length of wire.	Strain applied 1 foot from center.	Torsion.		Resilience in length of wire.	Highest strain.	Ultimate torsion in length of wire.	Strain reduced to correspond to cross section of 0″ .3 x 0″ .3.	Time of twisting.	Measurements of cross-section of wire.	Original mark on rods.	Remarks.
No. of experiment.	Material.			Under strain.	Released.								
		In.	*Lbs.*	*Turns.*	*Turns.*	*Turns.*	*Lbs.*	*Turns.*	*Lbs.*		*Inches.*		
298	C H...	1	12.00	0.0065	0.001	.0035	......	......	12.78	......	.2970 x .2983	......	
			13.00	0.007	0.0013	.0057	......	......	13.84	......	......	......	
			14.00	0.008	0.002	.006	......	......	14.91	......	......	......	
			15.00	0.0105	0.005	.0055	......	......	15.97	......	......	......	
			16.00	0.023	0.0175	.055	......	......	17.04	......	......	......	
							47.20	0.869	50.06	3.55	......	......	
299	C I...	1	12.00	0.0065	0.0015	.0055	......	......	12.16	......	.2980 x .2986	......	
			13.00	0.0075	0.002	.005	......	......	13.17	......	......	......	
			14.00	0.008	0.0025	.0055	......	......	14.18	......	......	......	
			15.00	0.012	0.0075	.0045	......	......	15.20	......	......	......	
			16.00	0.0245	0.018	.0065	......	......	16.21	......	......	......	
							47.00	0.910	47.62	4.00	......	......	
300	C J...	1	12.00	0.0065	0.0015	.0055	......	......	12.16	......	.2993 x .2980	......	
			13.00	0.007	0.0015	.0055	......	......	13.17	......	......	......	
			14.00	0.008	0.002	.006	......	......	14.19	......	......	......	
			15.00	0.009	0.003	.006	......	......	15.20	......	......	......	
			16.00	0.011	0.006	.005	......	......	16.21	......	......	......	
			17.00	0.021	0.016	.005	......	......	17.23	......	......	......	
			40.00	0.316	0.303	.013	......	......	40.54	......	......	......	
							49.50	0.838	50.17	1.43	......	......	
301	C K...	1	12.00	0.006	0.001	.005	......	......	12.20	......	.2978 x .2990	......	
			13.00	0.0065	0.001	.0055	......	......	13.21	......	......	......	
			14.00	0.007	0.001	.006	......	......	14.23	......	......	......	
			15.00	0.007	0.001	.006	......	......	15.25	......	......	......	
			16.00	0.008	0.0015	.0065	......	......	16.27	......	......	......	
			17.00	0.0085	0.002	.0065	......	......	17.28	......	......	......	
			18.00	0.010	0.003	.007	......	......	18.30	......	......	......	
			19.00	0.0105	0.0035	.0060	......	......	19.32	......	......	......	

			20.00	0.018	0.011	.007	......	......	20.33	......	......	......
			40.00	0.184	0.170	.014	......	......	40.67	......	......	......
							55.81	0.789	56.75	2.5	......	......
303	C L...	1	14.00	0.02	0.016	.004	......	......	......	......	.2978 x .2989	......
			40.00	0.940	0.929	.011	......	......	......	......	......	......
							40.98	1.157	41.08	......	......	......

TABLE 17.—*TORSIONAL TEST of specimen turned from gun-wire drawn from steel furnished by Messrs. Naylor & Co.*

Mark on specimen designating—		Length of specimen.	Strain applied 1 foot from center.	Torsion.		Resilience in length of specimen.	Strain reduced to correspond to diameter of 0″.3.	Time of twisting.	Diameter of specimen.	Remarks.
Number of experiment.	Material.			Under strain.	Released.					
			Lbs.	*Turns.*	*Turns.*	*Turns.*	*Lbs.*	*m. s.*	*In.*	
303	N co 1 s (D) 1 ...	1 inch between shoulders.	5.	0. 0035	0. 000	. 0035	5. 31		0. 2939	Wire turned in central part. Annealed at standard heat.
			6.	0. 0036	0. 000	. 0036	6. 38			
			6. 5	0. 004	0. 000	. 004	6. 91			
			7.	0. 004	0. 000	. 004	7. 44			
			7. 5	0. 004	0. 000	. 004	7. 97			
			8.	0. 0045	0. 000	. 0045	8. 50			
			8. 5	0. 005	0. 0005	. 0045	9. 03			
			9.	0. 006	0. 0005	. 0055	9. 57			
			9. 5	0. 006	0. 0005	. 0055	10. 10			
			10.	0. 0063	0. 0005	. 0058	10. 63			
			10. 5	0. 0065	0. 0005	. 0060	11. 16			
			11.	0. 0065	0. 001	. 0064	11. 69			
			11. 5	0. 0065	0. 0015	. 0050	12. 23			
			12.	0. 0245	0. 018	. 0065	12 76			
			13.	0. 030	0. 024	. 006	13. 82			
			14.	0. 038	0. 030	. 008	14. 88			
			15.	0. 047	0. 038	. 009	15. 95			
			16.	0. 056	0. 0475	. 0085	17. 01			
			17.	0. 068	0. 058	. 010	18. 07			
			18.	0. 0785	0. 069	. 0095	19. 13			
			19.	0. 092	0. 082	. 010	20. 20			
			20.	0. 107	0. 096	. 011	21. 27			
			21.	0. 123	0. 115	. 008	22. 33			
			22.	0. 142	0. 130	. 012	23. 39			
			23.	0. 164	0. 1515	. 0125	24. 46			
			24.	0. 1925	0. 179	. 0135	25. 52			
			25.	0. 2215	0. 219	. 0025	26. 58			
			26.	0. 260	0. 2475	. 0125	27. 65			
			27.	0. 311	0. 297	. 014	28. 71			
			28.	0. 3745	0. 359	. 0155	29. 77			
			29.	0. 4175	0. 432	. 0155	30. 84			

			30.	0.540	0.536	.004	31.90	*21	....	
			31.	0.652	0.637	.015	32.96	3 50	....	
			32.	0.714	0.699	.015	34.02	3 36	....	
			33.	0.870	0.855	.015	35.09	2 05	....	
			34.	1.076	....	....	36.15	3 55	†0.294	Broke while nearly standing at 34 lbs.

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* From the start until reaching 30 pounds.

† Diameter after breaking.

TABLE 18.—*TORSIONAL TEST of specimen turned from steel furnished by Messrs. Naylor & Co.*

Mark on specimen designating—		Length of turned part of specimen.	Strain applied 1 foot from center.	Torsion.		Resilience in length of wire.	Strain reduced to correspond to diameter of 0″.3.	Time of twisting.	Diameter.	Remarks.
Number of experiment.	Material.			Under strain.	Released.					
			Lbs.	*Turns.*	*Turns.*	*Turns.*	*Lbs.*	*m. s.*	*In.*	
304	N co 1 S (D) 2	1 inch	5.	0.003	0.000	.003	5.26	19	0.2949	Wire.—Central inch turned to 0.2949 diameter. Annealed at standard heat.
			5.5	0.0035	0.000	.0035	5.78	18	....	
			6.	0.0035	0.000	.0035	6.32	16	....	
			6.5	0.004	0.000	.004	6.84	21	....	
			7.	0.004	0.000	.004	7.36	17	....	
			7.5	0.004	0.000	.004	7.88	19	....	
			8.	0.0045	0.000	.0045	8.42	23	....	
			8.5	0.005	0.000	.005	8.94	20	....	
			9.	0.005	0.000	.005	9.48	18	....	
			9.5	0.006	0.000	.006	10.00	23	....	
			10.	0.006	0.000	.006	10.53	16	....	
			10.5	0.006	0.000	.006	11.05	17	....	
			11.	0.0062	0.000	.0062	11.58	11	....	
			11.5	0.0065	0.0005	.006	12.10	10	....	
			12.	0.024	0.0172	.0068	12.64	1 09	....	
			13.	0.030	0.023	.007	13.69	42	....	
			14.	0.0375	0.030	.0075	14.74	42	....	
			15.	0.046	0.0375	.0085	15.79	48	....	
			16.	0.055	0.0465	.0085	16.85	56	....	
			17.	0.0675	0.0575	.010	17.90	1 14	....	
			18.	0.078	0.0685	.0095	18.96	1 01	....	
			19.	0.091	0.080	.011	20.01	1 08	....	
			20.	0.105	0.094	.011	21.07	1 23	....	
			21.	0.120	0.1085	.0115	22.12	0 45	....	
			22.	0.139	0.1272	.0118	23.17	1 13	....	
			23.	0.1595	0.1475	.0120	24.23	1 02	....	
			24.	0.184	0.171	.013	25.28	1 03	....	
			25.	0.2155	0.202	.0035	26.33	1 30	....	
			26.	0.2495	0.2375	.0120	27.39	1 40	....	
			27.	0.2976	0.2835	.0141	28.44	2 50	....	
			28.	0.3485	0.335	.0135	294.9	1 48	....	

			29.	0. 420	0. 4064	. 0136	30. 55	2 05	....	
			30.	0. 503	0. 488	. 015	31. 60	2 45	....	
			31.	0. 617	0. 601	. 016	32. 65	5 55	....	
			32.	0. 7484	0. 732	. 0164	33. 71	6 02	....	
			33.	0. 8934	0. 8773	. 0161	34. 76	4 25	....	
			34.	1. 108	1. 0914	. 0166	35. 81	11 02	....	
			34. 40	1. 123	....	....	36. 24	0 17	*0. 2945	Broke.

* Diameter after breaking.

TABLE 19.—*TORSIONAL TEST of steel from Messrs. Miller, Barr & Parkin.*

Mark on specimen designating—		Length of turned part of specimen.	Strain applied 1 foot from center.	Torsion.		Resilience in length of specimen.	Strain reduced to correspond to diameter of 0''.3.	Time of twisting.	Diameter.	Remarks.
Number of experiment.	Material.			Under strain.	Released.					
			Lbs.	*Turns.*	*Turns.*	*Turns.*	*Lbs.*	*m. s.*	*In.*	
305	CRESCENT......	1 inch	5.	0. 003	0. 000	. 003	4. 94	29	0. 3012	This specimen was prepared from "Crescent" steel in use in the Ordnance-shops, Washington navy-yard. It was first planed to 0''. 3 square, and the central inch then turned to a cylinder 0''. 3012 diameter. Annealed at standard heat.
			5. 5	0. 0033	0. 000	. 0033	5. 43	20	......	
			6.	0. 0035	0. 000	. 0035	5. 92	23	......	
			6. 5	0. 0035	0. 000	. 0035	6. 42	19	......	
			7.	0. 0035	0. 000	. 0035	6. 91	17	......	
			7. 5	0. 004	0. 000	. 004	7. 41	16	......	
			8.	0. 004	0. 000	. 004	7. 90	16	......	
			8. 5	0. 004	0. 000	. 004	8. 39	22	......	
			9.	0. 0045	0. 000	. 0045	8. 89	18	......	
			9. 5	0. 0045	0. 000	. 0045	9. 38	18	......	
			10.	0. 005	0. 000	. 005	9. 88	16	......	
			10. 5	0. 0055	0. 000	. 0055	10. 37	17	......	
			11.	0. 0055	0. 000	. 0055	10. 86	20	......	
			11. 5	0. 006	0. 000	. 006	11. 36	22	......	
			12.	0. 006	0. 000	. 006	11. 85	16	......	
			12. 5	0. 006	0. 000	. 006	12. 35	17	......	
			13.	0. 0062	0. 000	. 0062	12. 84	17	......	
			13. 5	0. 0062	0. 000	. 0062	13. 33	15	......	
			14.	0. 0065	0. 000	. 0065	13. 83	14	......	
			14. 5	0. 0065	0. 000	. 0065	14. 32	16	......	
			15.	0. 0066	0. 000	. 0066	14. 82	18	......	
			15. 5	0. 007	0. 000	. 007	15. 31	16	......	
			16.	0. 007	0. 000	. 007	15. 80	13	......	
			16. 5	0. 007	0. 000	. 007	16. 30	12	......	
			17.	0. 007	0. 000	. 007	16. 79	18	......	
			17. 5	0. 0074	0. 000	. 0074	17. 29	13	......	
			18.	0. 008	0. 0002	. 0078	17. 78	13	......	
			18. 5	0. 008	0. 0002	. 0078	18. 27	16	......	
			19.	0. 008	0. 0003	. 0077	18. 77	14	......	
			19. 5	0. 008	0. 0005	. 0075	19. 26	14	......	
			20.	0. 0082	0. 0005	. 0077	19. 76	18	......	
			20. 5	0. 0082	0. 0005	. 0077	20. 25	17	......	

			21.	0.0083	0.001	.0073	20.76	20	....	
			21.5	0.015	0.0093	.0057	21.24	53	....	
			22.	0.021	0.0115	.0095	21.73	1 12	......	
			23.	0.0265	0.016	.0105	22.72	30	....	
			24.	0.030	0.019	.011	23.71	41	....	
			25.	0.033	0.0206	.0124	24.70	35	....	
			26.	0.036	0.024	.012	25.69	26	....	
			27.	0.040	0.027	.013	26.67	28	....	
			28.	0.043	0.030	.013	27.66	37	....	
			29.	0.047	0.033	.014	28.65	36	....	
			30.	0.051	0.037	.014	29.64	27	....	
			31.	0.056	0.040	.016	30.63	30	....	
			32.	0.060	0.044	.016	31.61	41	....	
			33.	0.0665	0.0485	.018	32.60	1 01	....	
			34.	0.071	0.053	.018	33.59	0 59	....	
			35.	0.0775	0.0585	.019	34.58	1 08	....	
			36.	0.084	0.0645	.0195	35.57	0 38	....	
			37.	0.091	0.071	.020	36.55	0 40	....	
			38.	0.0986	0.078	.0206	37.54	0 47	....	
			39.	0.107	0.0863	.0207	38.53	0 22	....	
			40.	0.119	0.097	.022	39.52	1 08	....	
			41.	0.1315	0.109	.0225	40.51	1 18	....	
			42.	0.146	0.123	.023	41.50	1 24	....	
			43.	0.162	0.130	.032	42.48	1 05	....	
			44.	0.184	0.161	.023	43.47	1 30	....	
			45.	0.213	0.188	.025	44.46	1 43	....	
			46.	0.249	0.224	.025	45.45	2 12	....	
			47.	0.301	0.277	.024	46.44	2 42	....	
			48.	0.374	0.351	.023	47.42	2 24	*0.3013	
			48.28	0.397	....	....	47.70	1 00	....	Broke.

* Diameter after breaking.

TABLE 20.—*TORSIONAL TESTS of turned specimen of chrome steel No. 3, made by Chrome Steel Company.*

Mark on specimen designating—		Length of turned part of specimen.	Strain applied 1 foot from center.	Torsion.		Resilience in length of specimen.	Strain reduced to correspond to diameter of 0″.3.	Time of twisting.	Diameter.	Remarks.
Number of experiment.	Material.			Under strain.	Released.					
			Lbs.	*Turns.*	*Turns.*	*Turns.*	*Lbs.*	*m. s.*	*In.*	
306	CHROME	1 inch........	5.0	0.003	0.000	.003	5.50	15	0.2990	No. 3 chrome steel from shop. Planed 0″.3 sq. (to fit clamps)—the central inch turned cylindrically. Annealed at standard heat.
			5.5	0.0033	0.000	.0033	5.55	15	....	
			6.0	0.0035	0.000	.0035	6.06	12	....	
			6.5	0.0035	0.000	.0035	6.56	10	....	
			7.0	0.0037	0.000	.0037	7.07	12	....	
			7.5	0.0039	0.000	.0039	7.57	14	....	
			8.0	0.0039	0.000	.0039	8.08	10	....	
			8.5	0.004	0.000	.004	8.58	8	....	
			9.0	0.004	0.000	.004	9.09	8	....	
			9.5	0.005	0.000	.005	9.59	14	....	
			10.	0.005	0.000	.005	10.10	15	....	
			10.5	0.0055	0.000	.0055	10.60	10	....	
			11.0	0.006	0.000	.006	11.11	9	....	
			11.5	0.006	0.000	.006	11.61	12	....	
			12.0	0.0065	0.0002	.0063	12.12	10	....	
			12.5	0.0065	0.0002	.0063	12.62	12	....	
			13.0	0.0065	0.0003	.0063	13.13	12	....	
			13.5	0.0066	0.0003	.0066	13.65	12	....	
			14.0	0.0067	0.0005	.0062	14.14	10	....	
			14.5	0.0069	0.0009	.0060	14.64	11	....	
			15.0	0.007	0.001	.006	15.15	10	....	
			15.5	0.007	0.001	.006	15.65	12	....	
			16.0	0.008	0.0012	.0068	16.16	10	....	
			16.5	0.0084	0.0013	.0071	16.66	9	....	
			17.0	0.009	0.0019	.0081	17.17	8	....	
			17.5	0.010	0.0025	.0075	17.67	10	....	
			18.0	0.011	0.003	.008	18.18	11	....	
			18.5	0.0115	0.0036	.0079	18.68	14	....	
			19.0	0.0126	0.005	.0076	19.19	13	....	
			19.5	0.014	0.0063	.0077	19.69	10	....	
			20.0	0.016	0.007	.009	20.20	10	....	
			20.5	0.0174	0.008	.0094	20.70	10	....	

			21. 0	0. 019	0. 009	. 010	22. 21	13	....	
			21. 5	0. 020	0. 010	. 010	21. 71	10	....	
			22.	0. 0214	0. 0115	. 0099	22. 22	10	....	
			23.	0. 025	0. 014	. 009	23. 23	24	....	
			24.	0. 029	0. 0175	. 0115	24. 24	14	....	
			25.	0. 032	0. 020	. 012	25. 25	13	....	
			26.	0. 037	0. 024	. 013	26. 26	20	....	
			27.	0 040	0. 028	. 012	27. 27	15	....	
			28.	0. 0445	0. 031	. 0135	28. 28	17	....	
			29.	0. 049	0. 0353	. 0137	29. 29	17	....	
			30.	0. 055	0. 040	. 015	30. 30	14	....	
			31.	0. 059	0. 044	. 015	31. 31	15	....	
			32.	0. 065	0. 049	. 016	32. 32	15	....	
			33.	0. 070	0. 054	. 016	33. 33	12	....	
			34.	0. 078	0. 060	. 018	34. 34	20	....	
			35.	0. 085	0. 068	. 017	35. 35	30	....	
			36.	0. 093	0. 074	. 019	36. 36	20	....	
			37.	0. 1015	0. 082	. 0195	37. 37	23	....	
			38.	0. 115	0. 0915	. 0235	38. 38	28	....	
			39.	0. 123	0. 103	. 020	39. 39	30	....	
			40.	0. 1385	0. 117	. 0215	40. 40	1 24	....	
			41.	0. 154	0. 132	. 022	41. 41	0 46	....	
			42.	0. 1755	0. 153	. 0225	42. 42	1 16	....	
			43.	0. 200	0. 177	. 023	43. 43	1 02	....	
			44.	0. 240	0. 217	. 023	44. 44	1 26	....	
			45.	0. 286	0. 262	. 014	45. 45	2 08	....	
			46.	0. 346	0. 321	. 025	46. 46	2 08	......	
			47.	0. 435	0. 410	. 025	47. 47	3 26	....	
			48.	0. 5263	....	....	48. 48	1 50	*0. 300	Broke.

* Diameter after breaking.

TABLE 21.—*TORSIONAL TEST of specimen turned from gun-wire drawn from steel furnished by Messrs. Naylor & Co.*

Mark on specimen designating—		Length of wire, (turned part.)	Strain applied 1 foot from center.	Torsion.		Resilience in length of wire.	Strain reduced to correspond to diameter of 0″.3.	Time of twisting.	Diameter.	Remarks.
No. of experiment.	Material.			Under strain.	Released.					
			Lbs.	*Turns.*	*Turns.*	*Turns.*	*Lbs.*	*m. s.*	*In.*	
307	N co 1 S (D) 1...	1 inch	1.50	0.004	0.000	.004	5.29	18	0.1970	0″.3 square wire, central inch turned to 0″.197 diameter. Annealed at standard heat.
			1.70	0.004	0.002	.002	5.99	12	....	
			1.90	0.007	0.002	.005	6.70	16	....	
			2.10	0.007	0.002	.005	7.40	10	....	
			2.30	0.0072	0.002	.0052	8.11	16	....	
			2.50	0.0076	0.002	.0056	8.81	14	....	
			2.70	0.008	0.002	.006	9.52	9	....	
			2.90	0.0085	0.0021	.0064	10.22	10	....	
			3.10	0.009	0.003	.006	10.93	9	....	
			3.30	0.011	0.004	.007	11.63	16	....	
			3.50	0.025	0.0152	.0098	12.34	32	....	
			4.00	0.046	0.038	.008	14.10	16	....	
			4.50	0.063	0.0535	.0095	15.87	20	....	
			5.00	0.083	0.0732	.0098	17.63	25	....	
			5.50	0.107	0.097	.010	19.39	32	....	
			6.00	0.1355	0.1246	.0109	21.16	28	....	
			6.50	0.171	0.158	.013	22.92	26	....	
			7.00	0.218	0.205	.013	24.68	28	....	
			7.50	0.280	0.266	.014	26.45	32	....	
			8.00	0.3675	0.352	.0155	28.21	47	....	
			8.50	0.4935	0.477	.0165	29.98	1 11	....	
			9.00	0.6784	0.661	.0174	31.74	1 46	....	
			9.50	0.947	0.928	.019	33.50	2 33	....	
			10.00	1.2785	1.259	.0195	35.27	3 50	....	
			10.50	1.748	....	....	37.03	3 51	*0.1963	Broke.

* Diameter after breaking.

TABLE 22.—*TORSIONAL TEST of specimen turned from gun-wire drawn from steel furnished by Messrs. Naylor & Co.*

Mark on specimen designating—		Length of wire, (turned part.)	Strain applied 1 foot from center.	Torsion.		Resilience in length of wire.	Strain reduced to correspond to diameter of 0″.3.	Time of twisting.	Diameter.	Remarks.
Number of experiment.	Material.			Under strain.	Released.					
			Lbs.	*Turns.*	*Turns.*	*Turns.*	*Lbs.*	*m. s.*	*In.*	
308	N co 1 S (D) 2...	1 inch	1.50	0.0032	0.000	.0032	4.98	22	0.2011	0″.3 wire, turned in central inch to diameter of 0″.2011. Standard heat.
			1.70	0.0035	0.000	.0035	5.54	10	....	
			1.90	0.0036	0.000	.0036	6.30	12	....	
			2.10	0.004	0.000	.004	6.97	13	....	
			2.30	0.0045	0.000	.0045	7.63	9	....	
			2.50	0.005	0.000	.005	8.30	9	....	
			2.70	0.005	0.000	.005	8.96	11	....	
			2.90	0.006	0.000	.006	9.62	10	....	
			3.10	0.006	0.000	.006	6.97	9	....	
			3.30	0.0062	0.000	.0062	10.95	8	....	
			3.50	0.0065	0.000	.0065	11.62	10	....	
			3.70	0.0066	0.000	.0066	12.28	10	......	
			3.90	0.032	0.025	.007	12.94	1 14	....	
			4.00	0.035	0.0275	.0075	13.28	19	....	
			4.50	0.050	0.040	.010	14.94	31	....	
			5.00	0.066	0.057	.009	16.60	48	....	
			5.50	0.085	0.0744	.0106	18.26	43	....	
			6.00	0.1075	0.0965	.0110	19.92	57	....	
			6.50	0.1335	0.122	.0115	21.58	53	....	
			7.00	0.1675	0.155	.0125	23.24	1 00	....	
			7.50	0.210	0.1965	.0135	24.90	53	....	
			8.00	0.268	0.252	.016	26.56	1 5	....	
			8.50	0.3435	0.3285	.0150	28.22	1 23	....	
			9.00	0.448	0.432	.016	29.88	1 30	....	
			9.50	0.6075	0.590	.0175	31.54	2 13	....	
			10.00	0.834	0.817	.017	33.20	2 40	....	
			10.50	1.108	0.900	.208	34.86	3 23	....	
			11.00	1.497	1.479	.018	36.52	4 00	....	
			11.33	1.647	....	....	37.61	14	*0.2011	Broke.

* Diameter after breaking.

TABLE 23.—*TORSIONAL TEST of specimen turned from steel made by Messrs. Miller, Barr & Parkin.*

Mark on specimen designating—		Length of turned part of specimen.	Strain applied 1 foot from center.	Torsion.		Resilience in length of specimen.	Strain reduced to correspond to diameter of 0″.3.	Time of twisting.	Diameter.	Remarks.
Number of experiment.	Material.			Under strain.	Released.					
			Lbs.	*Turns.*	*Turns.*	*Turns.*	*Lbs.*	*m. s.*	*In.*	
309	CRESCENT	1 inch.........	1.50	0.0038	0.000	.0038	5.10	19	0.1995	Planed from "Crescent steel" of shops to 0″.205 square to fit clamps; central inch turned to 0″.1995 diameter. Annealed at standard heat.
			1.70	0.004	0.000	.004	5.78	9	....	
			1.90	0.005	0.000	.005	6.46	9	....	
			2.10	0.005	0.000	.005	7.14	10	....	
			2.30	0.0055	0.000	.0055	7.82	12	....	
			2.50	0.006	0.000	.006	8.50	8	....	
			2.70	0.006	0.000	.006	9.18	13	....	
			2.90	0.0063	0.000	.0063	9.86	11	....	
			3.10	0.0065	0.000	.0065	10.54	8	....	
			3.30	0.0066	0.000	.0066	11.22	10	....	
			3.50	0.007	0.000	.007	11.90	14	....	
			3.70	0.007	0.000	.007	12.58	14	....	
			3.90	0.0074	0.000	.0074	13.26	10	....	
			4.10	0.0075	0.000	.0075	13.94	14	....	
			4.30	0.0076	0.000	.0076	14.62	9	....	
			4.50	0.008	0.000	.008	15.30	12	....	
			4.70	0.0082	0.000	.0082	15.98	14	....	
			4.90	0.0085	0.0005	.008	16.66	8	....	
			5.10	0.009	0.001	.008	17.34	10	....	
			5.30	0.010	0.001	.009	18.02	11	....	
			5.50	0.010	0.001	.009	18.70	13	....	
			5.70	0.010	0.001	.009	19.38	13	....	
			5.90	0.0105	0.001	.0095	20.06	11	....	
			6.10	0.011	0.0014	.0096	20.74	14	....	
			6.30	0.0155	0.0075	.0080	21.42	18	....	
			6.50	0.035	0.025	.010	22.10	32	....	
			7.00	0.043	0.027	.016	23.80	32	....	
			7.50	0.051	0.035	.016	25.50	48	....	
			8.00	0.059	0.042	.017	27.20	11	....	
			8.50	0.068	0.050	.010	28.90	12	....	
			9.00	0.078	0.058	.020	30.60	13	....	
			9.50	0.0685	0.067	.0215	32.30	10	....	

			10. 00	0. 1015	0. 078	. 0235	34. 00	17	....	
			10. 50	0. 1165	0. 0915	. 0250	35. 70	35	....	
			11. 00	0. 135	0. 1075	. 0275	37. 40	43	....	
			11. 50	0. 158	0. 130	. 028	39. 10	50	....	
			12. 00	0. 1875	0. 157	. 0305	40. 90	1 04	....	
			12. 50	0. 226.	0. 196	. 030	42. 50	1 09	....	
			13. 00	0. 2835	0. 253	. 0305	44. 20	1 26	....	
			13. 50	0. 369	0. 338	. 031	45. 90	1 55	....	
			14. 00	0. 568	....	....	47. 60	3 50	*0. 1998	Broke.

* Diameter after breaking.

TABLE 24.—*TORSIONAL TEST of specimen turned from chrome steel made by the Chrome Steel Company.*

Mark on specimen designating—		Length of turned part of specimen.	Strain applied 1 foot from center.	Torsion.		Resilience in length of specimen.	Strain reduced to correspond to diameter of 0″.3.	Time of twisting.	Diameter.	Remarks.
Number of experiment.	Material.			Under strain.	Released.					
			Lbs.	*Turns.*	*Turns.*	*Turns.*		*m. s.*	*In.*	
310	CHROME	1 inch.........	1.50	0.0035	0.000	.0035	5.21	15	0.1980	Planed to 0″.204 square to fit clamp; central inch turned to diameter of 0″.198. No. 3 chrome steel of the ordnance-shops. Annealed at standard heat.
			1.70	0.004	0.000	.004	5.91	12	....	
			1.90	0.0045	0.000	.0045	6.50	10	....	
			2.10	0.005	0.000	.005	7.30	12	....	
			2.30	0.0055	0.000	.0055	8.00	16	....	
			2.50	0.006	0.000	.006	8.71	9	....	
			2.70	0.0063	0.000	.0063	9.41	9	....	
			2.90	0.0065	0.000	.0065	10.08	9	....	
			3.10	0.0066	0.0005	.0061	10.78	10	....	
			3.30	0.007	0.001	.006	11.47	10	....	
			3.50	0.007	0.001	.006	12.17	16	....	
			3.70	0.0074	0.001	.0064	12.87	10	....	
			3.90	0.008	0.001	.007	13.56	10	....	
			4.10	0.0081	0.001	.0071	14.26	10	....	
			4.30	0.0085	0.0011	.0075	14.95	13	....	
			4.50	0.009	0.0013	.0077	15.65	9	....	
			4.70	0.010	0.0018	.0082	16.34	7	....	
			4.90	0.011	0.002	.009	17.04	11	....	
			5.10	0.012	0.003	.009	17.73	17	....	
			5.30	0.014	0.0036	.0104	18.43	11	....	
			5.50	0.016	0.0064	.0096	19.13	15	....	
			5.70	0.018	0.0075	.0105	19.82	12	....	
			5.90	0.0205	0.010	.0105	20.52	13	....	
			6.00	0.022	0.011	.011	20.87	13	....	
			6.50	0.029	0.0165	.0125	22.60	8	....	
			7.00	0.0372	0.023	.0142	24.34	9	....	
			7.50	0.046	0.030	.016	26.08	10	....	
			8.00	0.056	0.0385	.0175	27.82	17	....	
			8.50	0.066	0.048	.018	29.56	11	....	
			9.00	0.078	0.058	.020	31.30	18	....	
			9.50	0.091	0.070	.021	33.04	22	....	
			10.00	0.105	0.083	.022	34.78	19	....	

10. 50	0. 122	0. 0985	. 0235	36. 52	17	....	
11. 00	0. 143	0. 117	. 026	38. 96	37	....	
11. 50	0. 172	0. 143	. 029	40. 00	44	....	
12. 00	0. 205	0. 176	. 029	41. 74	51	....	
12. 50	0. 2535	0 223	. 0305	43. 48	1 21	....	
13. 00	0. 324	0. 297	. 031	45. 21	1 14	....	
13. 50	0. 456	0. 424	. 032	46. 95	2 52	....	
14. 00	0. 667	0. 637	. 030	48. 69	2 57	....	
14. 41	0. 786	....	....	50. 12	18	*0. 199	Broke.

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* Diameter after breaking.

TABLE 25.—*TORSIONAL TESTS of square specimens planed from steel wire-rods.*

Mark on specimen designating—		Strain applied.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-sections.	Strain reduced to correspond to cross-section of 0″.3 x 0″.3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
311	C M ROD	13.42	0.0065	0.0015	0.0050		0.3023 x .3030	13.06	These specimens were planed from wire-rods furnished by Messrs. Hussey, Welles & Co. All were intended to be of the same quality. They were annealed at a heat between the melting points of bronze and copper. Length between clamps, 1 inch. The time noted commenced with the application of strain next following a torsion of 0.01.
		14.28	.0075	.0025	.0050			13.90	
		15.00	.014	.009	.005			14.60	
		48.68	0.627			7 45		47.40	
312	C N ROD	12.84	.006	.001	.005		.3034 x .3018	12.53	
		13.65	.0065	.0015	.005			13.32	
		14.40	.009	.006	.003			14.06	
		47.33	.634			6 38		46.19	
313	C O ROD	13.43	.0065	.0015	.0050		.303 x .3036	12.99	
		14.36	.0085	.003	.0055			13.89	
		15.50	.0105	.0055(?)	.005			14.99	
		48.63	.601			6 20		47.04	
314	C P ROD	13.35	.0065	.001	.0055		.3015 x .3030	13.05	
		14.35	.008	.0025	.0055			14.03	
		15.25	.011	.0065	.0045			14.91	
		50.24	.574			6 30		49.12	
315	C Q ROD	13.52	.006	.001	.005		.301 x .3012	13.37	
		14.60	.007	.0015	.0055			14.44	
		15.53	.009	.005	.004			15.36	
		49.66	.534			6 25		49.12	
316	C R ROD	13.00	.0065	.0025	.004		.302 x .299	12.93	
		13.70	.011	.008	.003			13.63	
		41.05	.759			5 34		40.84	
317	C S ROD	13.51	.007	.0015	.0055		.302 x .3025	13.21	
		14.40	.010	.006	.004			14.08	
		47.57	.629			6 38		46.51	

318	C T ROD	12.34	.006	.0015	.0045		.2984 x .3013	12.40	
		13.25	.010	.0065	.0035			13.31	
		45.20	.625			7 23		45.43	
319	C U ROD	13.43	.0063	.002	.0043		.3014 x .3008	13.28	
		14.46	.010	.0065	.0035			14.30	
		44.00	.693			5 55		43.51	
320	C V ROD	13.24	.0074	.002	.0054		.302 x .3003	13.08	
		14.00	.010	.0065	.0035			13.83	
		47.14	.631			8 19		46.59	Broke.
321	C E ROD	13.34	0.006	0.001	.005		.299 x 0.300	13.40	
		14.50	0.007	0.0015	.0055			14.57	
		15.49	0.010	0.0035	.0065			15.56	
		16.00	0.011	0.0040	.007			16.08	
		16.50	0.012	0.0065	.0055			16.58	
		17.00	0.016	0.008	.008			17.08	
		17.50	0.0165	0.009	.0075			17.58	
		18.00	0.018	0.011	.007			18.09	
		50.34	0.500	0.4825	.0175			50.59	
						3 35		52.12	
		57.87		0.570				58.15	
322	C F ROD	14.50	0.007	0.0015	.0055		.292 x 0.295	15.14	
		15.00	0.008	0.002	.006			15.67	
		15.50	0.0085	0.0025	.006			16.19	
		16.00	0.010	0.0035	.0065			16.71	
		16.50	0.0115	0.0065	.005			17.23	
		17.00	0.017	0.0115	.0055			17.76	
		44.18	0.500	0.4850	.015			46.15	
		47.56	0.679			3 38		49.69	
323	C K ROD	16.90	0.007	0.001	.006		.298 x 0.299	17.34	
		17.40	0.008	0.0015	.0065			17.86	
		17.90	0.008 +	0.002 –	.006			18.37	
		18.40	0.009	0.002	.007			18.88	
		18.90	0.009	0.002 +	.007 –			19.40	
		19.40	0.010	0.003	.007			19.71	
		19.90	0.011	0.003	.008			20.42	
		20.40	0.0115	0.0035	.007			20.94	
		20.90	0.012	0.005	.007			21.45	
		21.40	0.013	0.0065	.0065			21.96	
		21.90	0.015	0.007	.008			22.48	
		22.40	0.017	0.0085	.0085			23.09	
		22.90	0.019	0.010	.008			23.50	
		57.68	0.500	0.482	.018			59.11	
		58.24	0.538			3 50		59.78	

TABLE 25.—*TORSIONAL TESTS of specimens planed from wire-rods*—Continued.

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.			Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0".3 x 0".3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.	Resilience.				
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
321	C L ROD	13.45	0.0065	0.001	0.0055		.2987 x .2943	13.93	
		13.95	.007	.001 +	.006			14.44	
		14.45	.008	.002	.006			14.96	
		14.95	.009	.004	.005			15.48	
		15	.010	.008	.002			15.53	
		15.50	.0175	.012	.0055			16.05	
		41.45	.50	.486	.014			42.93	
		44.00	.635			3 15		45.57	
325	C S co 5 ROD	15.40	0.007	0.001	0.006		.2975 x 0.2962	15.88	
		15.90	.0075	.0015	.0055			16.40	
		16.40	.0085	.002	.0065			16.92	
		16.90	.010	.0035	.0065			17.43	
		17.40	.0115	.0045	.007			17.95	
		17.90	.013	.007	.006			18.46	
		18.40	.016	.0085	.0065			18.98	
		18.90	.017	.010	.007			19.50	
		52.05	.456			3 15		53.70	
326	C H co 4 S ROD	15.81	0.0065	0.0005	0.006		.300 x 0.293	16.35	
		16.50	.007	.001	.006			17.06	
		17.00	.007 +	.001 +	.006			17.58	
		17.50	.008	.0015	.0065			18.09	
		18.00	.008 +	.002	.006 +			18.61	
		18.50	.009	.0025	.0065			19.13	
		19.00	.010	.0035	.0065			19.64	
		19.50	.011 +	.004	.007 +			20.16	
		20.00	.012	.006	.006			20.68	
		20.50	.014	.007	.007			21.20	
		21.00	.016	.0085	.0075			21.71	
		21.50	.0175	.010	.0075			22.23	
		54.16	.498			3 50		58.01	

387	N oo I ROD	10.36	0.005	0.0025	0.0025		.2985 x 0.299	10.48
		10.36	.030	0.0265	.0035			10.48
		96.87	.500	.496	.004			97.90
		32.69	1.910			3 55		33.09

TABLE 26.—*TORSIONAL TESTS of steel gun-wires.*

[For explanation of marks, see pages 136 to 140, inclusive.]

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0″.3 x 0″.3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
328	C H co 4 S	13.70	0.007	0.0015	0.0055		.293 x .295	14.55	The time noted in this experiment and in the succeeding ones, up to and including No. 342, commenced with the beginning of the next strain after reaching a "released torsion" of 0.01, and includes the whole time the specimen was under strain, up to breaking. The strain given was continued until specimens ceased yielding.
		14.50	.008	.002	.006			15.40	
		15.00	.009	.0025	.0065			15.93	
		15.50	.010	.0035	.0065			16.46	
		16.00	.011	.005	.006			16.99	
		16.50	.0155	.0085	.007			17.52	
		17.00	.018	.0115	.0065			18.26	
		45.96	.522	.517	.005			48.82	
		50.65	.834			5 15		53.81	
329	C S co 5	13.37	0.0065	0.001	0.0055		.294 x .296	14.06	
		14.00	.007	.001 +	.006 –			14.72	
		14.50	.0075	.0015	.006			15.24	
		15.00	.008 +	.002	.006 +			15.77	
		15.50	.009	.0035	.0055			16.30	
		15.60	.013	.007	.006			16.40	
		16.00	.015	.008	.007			16.82	
		16.50	.018	.011	.007			17.35	
		47.88	.500	.481	.019			50.35	
		50.05	.627			4 30		52.63	
330	C M	12.90	0.0065	0.001	0.0055		.2991 x .300	12.95	
		13.50	.007	.0015	.0055			13.56	
		14.00	.007 +	.002	.005 +			14.06	
		14.50	.0085	.0035	.005			14.56	
		14.50	.019	.012	.007			14.56	
		43.00	.500	.487	.013			43.19	
		46.88	.738			4 2		47.09	
331	C N	13.30	0.0065	0.001 +	0.0055–		.2992 x .2987	13.13	
		13.50	.007	.002	.005			13.64	
		14.00	.008	.003	.005			14.14	

		14.05	.010	.0065	.0035			14.19
		14.50	.018	.013	.005			14.65
		41.69	.501	.488	.013			42.12
		45.00	.7175			4 5		45.47
332	C O	12.00	0.0065	0.001	.0055		.2975 x .300	12.14
		12.50	.007	.0015	.0055			12.65
		13.00	.007 +	.0015+	.0055			13.16
		13.50	.0075	.002	.0055			13.66
		14.00	.008	.003	.005			14.17
		14.50	.010	.0065	.0035			14.67
		15.00	.018	.013	.005			15.18
		42.56	.500	.487	.013			43.08
		46.00	.728					46.57
333	C P	12.50	0.0065	0.001	0.0055		.2993 x .2973	12.71
		13.00	.0065	.001	.0055			13.22
		13.50	.007	.0015	.0055			13.73
		14.00	.007 +	.002 −	.005 +			14.24
		14.50	.008	.0025	.0055			14.75
		15.00	.009	.005	.004			15.26
		15.00	.018	.0115	.0065			15.26
		43.29	.500	.485	.015			44.04
		47.00	.677			4 25		47.81
334	C Q	12.50	0.006	0.001 −	.005 +		.2984 x .2988	12.67
		13.00	.006 +	.001	.005 +			13.18
		13.50	.0065	.001 +	.0055−			13.69
		14.00	.007	.0015	.0055			14.19
		14.50	.0075	.002	.0055			14.70
		15.00	.008	.004 −	.004 +			15.21
		15.00	.015	.005	.010			15.21
		46.47	.601	.584	.017			47.12
		47.24	.654			3 55		47.90
335	C R	12.25	0.0065	0.001	.0055		.2975 x .299	12.46
		13.00	.0065	.001 +	.0055−			13.23
		13.50	.007	.002 −	.005 +			13.73
		14.00	.008	.003	.005			14.24
		14.00	.010	.007	.003			14.24
		14.50	.018	.013	.005			14.75
		35.05	.500	.488 +	.012			35.67
		41.00	.874			3 50		41.72
336	C S	12.70	0.007 −	0.0015	.0055−		.2993 x .300	12.73
		13.50	.007	.002	.005			13.54
		14.00	.008	.0025+	.0055−			14.04
		14.50	.010	.0065	.0035			14.54
		41.32	.501	.489	.012			41.44
		45.40	.734			4 20		45.53

TABLE 26.—*TORSIONAL TESTS of steel gun-wires*—Continued.

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0″.3 x 0″.3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
337	C T	12.00	0.006	0.001 —	0.005 +		.2993 x .2995	12.07	
		12.50	.0063	.001	.0055			12.57	
		13.00	.0065+	.001 +	.0055			13.07	
		13.50	.007	.002 —	.005 +			13.58	
		14.00	.008	.003	.005			14.08	
		14.08	.010	.007	.003			14.16	
		14.50	.019	.015	.004			14.58	
		40.52	.500	.4875	.0125			40.76	
		45.05	.754			3 40		45.32	
338	C U	11.95	0.006	0.001	.005			12.12	
		12.50	.0065	.001 +	.0055—		.2978 x .2993	12.68	
		13.00	.0065	.001 +	.0055—			13.18	
		13.50	.0065+	.0015	.005 +			13.69	
		14.00	.007	.002	.005			14.20	
		14.50	.0085+	.005	.0035+			14.71	
		14.50	.031	.0255	.0055			14.71	
		37.82	.502	.4875	.0145			38.37	
		42.57	.840			3 50		43.19	
339	C V	11.00	0.005	0.001 —	.004 +		.29[illegible] x .2984	11.14	
		15.50	.006	.001	.005			15.70	
		12.00	.0065	.001 +	.0055—			12.15	
		12.50	.0065	.0015	.005			12.66	
		13.00	.0065+	.0015	.005 +			13.17	
		13.50	.0075	.002	.0055			13.67	
		14.00	.008	.003	.005			14.18	
		14.50	.010	.0065	.0035			14.68	
		40.93	.500	.487	.013			41.46	
		45.00	.751			3 50		45.58	
340	C H co. 4 S	12.50	0.006 +	0.0005	0.0055+		.2933 x .2957	13.91	Numbers 340 and 341 were cut from different ends of the coil. After being twisted, both showed a slight seam.
		13.00	.0065	.001	.0055			13.74	

		13.50	.0065+	.001	.0055+	....	....	14.96
		14.00	.007	.001	.006	....	....	14.79
		14.50	.0075	.001 +	.0065—	....	....	15.32
		15.00	.008	.0015	.0065	....	....	15.85
		15.50	.0085	.002 —	.0065+	....	....	16.38
		16.00	.009	.002 +	.007 —	....	....	16.91
		16.50	.010	.003	.007	....	....	17.44
		17.00	.011	.0035	.0065	....	....	17.96
		18.00	.014	.007	.007	....	....	19.02
		19.00	.0185	.0105	.007	....	....	20.08
		48.75	.500	.483	.017	....	....	51.52
		53.29	.883	....	....	4 20	....	56.32
341	C H co 4 S	12.80	0.0065	0.001 —	0.0055—	....	....	13.60
		13.30	.0065+	.001	.0055+	....	.2924 x .2955	14.13
		13.80	.007	.001	.006	....	....	14.67
		14.30	.007	.001	.006	....	....	15.20
		14.80	.0075+	.001 +	.0065	....	....	15.73
		15.30	.008 +	.0015	.0065+	....	....	16.26
		16.00	.0085	.002	.0065	....	....	17.00
		16.50	.010	.0025+	.0075—	....	....	17.54
		17.00	.0105	.003	.0075	....	....	18.07
		18.00	.014	.0075	.0065	....	....	19.13
		46.53	.501	.479	.022	....	....	49.46
		52.76	.900	....	....	3 55	....	56.08
342	B B..................	17.00	0.010 —	0.003 +	0.007 —	....	.3009 x .3014	16.80
		18.00	.0115—	.005	.0065	....	....	17.79
		19.00	.015	.007	.008	....	....	18.78
		51.87	.500	.480	.020	....	....	51.27
		56.03	.785	....	....	4 10	....	55.39
348	P B co 2 *	13.40	0.010	0.004	.006	....	.2989 x .3001	13.46
		14.00	.012	.0065	.0055	....	....	14.07
		14.50	.015	.008	.007	....	....	14.57
		15.00	.017	.01 +	.007	....	....	15.07
		42.70	.500	.484	.016	6 48	....	42.91
		45.90	.6285	....	....	0 28	....	46.12
349	P B co 3 *	13.30	.010	.004	.006	2 10	.2985 x .2997	13.31
		14.00	.013	.008	.005	1 40	....	14.01
		14.50	.016	.010	.006	1 30	....	14.51
		42.05	.500	.485	.015	9 45	....	42.06
		45.50	.639	....	....	0 30	....	45.54

The time here given is counted from the beginning of the next strain after reaching 0.01 permanent torsion.

Torsion due to continuance of this strain was reached.

Torsion due to continuance of this strain was reached.

TABLE 26.—*TORSIONAL TESTS of steel gun-wires*—Continued.

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0″.3 x 0″.3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
350	A co 2*	20.60	.010	.0038	.0062	3 20	.2985 x .3002	20.73	In this experiment, and in the subsequent ones recorded in this table, unless otherwise mentioned, the torsions preceding and including that of 0.01 "*released*" were very nearly those due to a continuance of the strain given. The strain at the torsion of 0.500 was taken when that torsion was reached in the course of turning at the rate of an entire revolution in about five minutes. It was then immediately released and "*released torsion*" read. Subsequently the torsion was continued at nearly the same rate, (or as nearly as the strain could be kept in adjustment,) until the piece failed.
		21.00	.017	.010	.007	1 00		21.13	
		50.97	.501	.485	.016	2 20		51.30	
		53.79	.6465			0 23		54.13	
351	M co 1*	15.00	.010	.006	.004	1 00	.302 x .3006	14.81	
		15.70	.028	.023	.005	0 50		15.50	
		38.93	.501	.489	.012	2 48		38.43	
		43.00	.778			0 50		42.45	
352	D L*	19.00	0.010	0.003	.007	†1 20	.3023 x .302	18.59	From Hussey, Welles & Co.
		20.00	.012	.005	.007	1 00		19.57	
		21.00	.015	.0065	.0075	0 53		20.55	
		22.00	.017	.008	.009	0 50		21.53	
		23.00	.019	.010	.009	0 34		22.51	
		61.51	.434			4 05		60.15	
353	D M*	14.52	.010	.004	.006	1 18	.2995 x .3010	14.48	
		15.00	.012	.0065	.0055	0 30		14.96	
		16.00	.0155	.009	.0065	0 30		15.96	
		16.50	.017	.010	.007	0 30		16.45	
		51.90	.50	.480	.02	5 05		51.77	
		53.81	.619			0 28		53.67	
354	D N*	17.50	.010	.003	.007	1 15	.3025 x .305	16.85	
		18.50	.011	.004	.007	1 00		17.82	
		19.50	.013	.006	.007	0 25		18.78	
		20.50	.0155	.008	.0075	0 40		19.74	
		21.50	.0175	.009	.0085	0 35		20.71	
		22.50	.020	.011	.009	0 30		21.67	
		61.11	.4275			3 30		58.87	
355	D O*	15.20	0.010	0.0035	.0065	1 10	.301 x .3012	15.03	

		16.90	.016	.009 —	.007	1 03		16.09	
		16.80	.0175	.0105	.007	0 55		16.61	
		53.00	.500	.480	.020	3 45		52.41	
		54.69	.5785			0 45		54.01	
356	D P*	16.69	0.010	0.0035	.0065	1 25	0.302 x 0.3039	16.21	
		17.69	.016	.009	.007	1 52		17.18	
		18.19	.017	.010	.007	0 55		17.67	
		55.53	.501	.481	.02	3 32		53.94	
		57.24	.596			0 18		55.60	
357	D Q*	13.23	0.010	0.004	.006	1 48	0.298 x 0.298	13.49	
		14.23	.034	.029	.005	1 05		14.51	
		36.46	.550	.548	.002	2 35		37.19	
		39.79	.791			0 37		40.59	
358	D R*	13.45	0.010	0.005	.005	1 00	0.2933 x 0.2933	14.39	
		14.45	.031	.0255	.0055	0 58		15.46	
		38.84	.501	.487	.014	2 45		41.56	
		42.41	.757			0 40		45.38	
359	D S*	13.00	0.032	0.0265	.0055	1 20	0.2985 x 0.2982	13.32	13.00 pounds were raised before 0.01 torsion was reached.
		34.61	.500	.488	.012	2 39		35.29	From Newark Steel Works.
		38.92	.830			0 40		39.58	
360	D T*	11.78	0.010	0.006	.004	0 32	0.2989 x 0.2989	11.90	
		12.78	.025	.020	.005	1 00		12.92	
		35.64	.501	.4885	.0125	2 20		36.03	
		39.52	.7955			0 48		39.95	
361	D U*	11.35	0.010	0.005	.005	1 18	0.2974 x 0.298	11.61	
		12.35	.0335	.0285	.005	1 00		12.63	
		32.84	.500	.488	.012	2 40		33.60	
		36.94	.817			0 42		37.80	
362	C co 1*	14.48	0.010	0.004	.006	2 20	0.2967 x 0.2987	14.81	Nos. 362 to 371, inclusive, were annealed together.
		15.48	.020	.013	.007	1 10		15.84	
		45.80	.501	.485	.016	3 45		46.86	
		46.94	.583			0 18		48.03	
363	C co 2*	14.60	0.010	0.004	.006	2 38	0.298 x 0.298	14.89	
		15.60	.020	.014	.006	1 20		15.91	
		45.83	.501	.483	.017	3 00		46.75	
		47.00	.573			0 20		47.94	
364	C co 3*	14.39	0.010	0.0035	.0065	1 30	0.297 x 0.2986	14.71	
		15.39	.019	.012	.007	1 00		15.73	
		45.85	.500	.4835	.0165	3 15		46.88	
		46.94	.565			0 15		47.99	

† About.

TABLE 26.—*TORSIONAL TESTS of steel gun-wires*—Continued.

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0".3 x 0".3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
365	C co 4✱	14.16	0.010	0.004	.006	2 20	0.3008 x 0.3011	14.09	
		15.16	.017	.010	.007	0 55		15.09	
		46.52	.501	.484	.017	3 50		46.31	
		48.61	.611			0 20		48.40	
366	C co 5✱	14.00	0.010	0.004	.006	1 40	0.2989 x 0.2972	14.27	
		15.00	.017	.0105	.0065	1 00		15.29	
		45.45	.500	.483	.017	3 15		46.34	
		46.90	.587			0 18		47.82	
367	C co 6✱	14.50	0.010	0.004	.006	1 52	0.301 x 0.300	14.42	
		15.50	.015	.009	.006	1 15		15.42	
		16.00	.0175	.011	.0065	1 00		15.92	
		47.72	.501	.484	.017	3 40		47.48	
		48.05	.541			0 12		47.81	
368	C co 7✱	15.00	0.010	0.0035	.0065	2 10	0.2985 x 0.2993	15.16	
		16.00	.020+	.0140	.0060	1 00		16.07	
		46.74	.501	.484	.017	3 45		47.25	
		48.00	.5865			0 40		48.52	
369	C co 8✱	15.00	0.010	0.0035	.0065	2 05	0.3001 x 0.3003	14.96	
		16.00	.018	.011	.007	1 25		15.96	
		48.36	.501	.484	.017	3 50		48.25	
		49.50	.573			0 10		49.39	
370	C co 9✱	14.20	0.010	0.004	.006	1 55	0.298 x 0.298	14.48	
		15.20	.020	.013	.007	1 00		15.50	
		45.34	.500	.4825	.0175	3 50		46.24	
		46.86	.591			0 25		47.80	
371	C co 10✱	14.80	0.010	0.004	.006	1 30	0.2985 x 0.2987	14.95	Nearly ceased yielding at a strain of 14.80.
		15.80	.0195	.013	.0065	1 40		15.96	
		47.50	.500	.483	.017	3 20		47.99	

		48.28	.559			0 10		48.79	
372	A co 2*	20.12	.010	.0025	.0075	4 10	0.3001 x 0.2989	20.22	
		21.12	.0245	.017	.0075	4 20		21.22	
		50.75	.500	.485	.015	3 05		51.00	
		53.52	.668			0 38		53.78	
373	M co 1*	14.50	.010	.0045	.0055	1 30	0.3006 x 0.303	14.14	Lever standing at 14.50.
		15.50	.035	.029	.006	1 45		15.22	Nearly ceased yielding at a torsion of .017, then began to yield more rapidly, without increasing the strain.
		38.47	.501	.488	.013	2 35		37.78	
		41.92	.735			0 40		41.73	
374	D L*	21.60	.01	.002	.008	4 00	0.3056 x 0.3029	19.93	
		22.60	.0115	.003	.0065	0 40		20.86	
		23.60	.0125	.004	.0085	0 35		21.78	
		24.60	.015	.0065	.0085	0 30		22.70	
		25.60	.017	.0075	.0095	0 30		23.63	
		26.60	.0195	.009	.0105	0 35		24.55	
		27.60	.0215	.0115	.010	0 45		25.47	
		64.14	.382			4 00		59.20	
375	D M*	16.85	.01	.003	.007	2 00	0.2996 x 0.301	16.79	
		17.85	.0135	.007	.0065	1 45		17.79	
		18.85	.018	.010	.008	1 30		18.79	
		53.42	.500	.479	.021	4 20		53.25	
		54.61	.562			0 15		54.44	
376	D N*	20.29	.01	.002	.008	3 10	0.3048 x 0.302	20.09	
		21.29	.011	.003	.008	0 30		21.08	
		22.29	.012	.004	.008	0 32		22.07	
		23.29	.014	.006	.008	0 35		23.06	
		24.29	.016	.007	.009	0 25		24.05	
		25.29	.018	.0085	.0095	0 25		25.04	
		26.29	.0205	.015	.0055	0 30		26.03	
		64.14	.426			4 35		63.52	
377	D O*	17.35	.01	.003	.007	2 10	0.3012 x 0.2994	17.29	
		18.35	.013	.0065	.0065	0 55		18.29	
		19.35	.017	.009	.008	1 10		19.29	
		20.35	.020	.0115	.0085	0 40		20.28	
		55.00	.501	.481	.020	3 10		54.83	
378	D P*	15.75	.01	.0035	.0075	3 30	0.3036 x 0.3017	15.33	
		16.75	.012	.0065 –	.0055	0 40		16.30	
		17.75	.0175	.0085	.0090	1 00		17.28	
		18.75	.019	.011	.008	1 00		18.25	
		55.20	.501	.481	.020	3 00		51.79	
		55.76	.542			0 05		54.28	

TABLE 26.—*TORSIONAL TESTS of steel gun-wires*—Continued.

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0″.3 x 0″.3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
379	D Q*	13.55	.025	.019	.006	*5 00	.2979 x .2976	13.85	
		36.41	.500	.488	.012	2 45		37.24	
		40.00	.765			0 40		40.91	
380	D R*	12.95	.01	.004	.006	2 00	.298 x .298	13.21	
		13.95	.029	.022	.007	1 00		14.23	
		38.65	.500	.486	.014	3 20		39.43	
		42.00	.735			0 35		42.84	
381	D S*	11.00	.016	.011	.005	2 00	.2978 x .2981	11.22	
		33.76	.500	.489	.011	2 55		34.45	
		37.69	.802			0 50		38.47	
382	D T*	11.75	.011	.0065	.0045	1 15	.2973 x .298	11.98	
		12.75	.029	.024	.005	1 05		13.00	
		35.19	.500	.488	.012	2 30		35.89	
		38.73	.769			0 45		39.50	
383	D U *	11.25	.023	.018	.005	3 00	.2976 x .2972	11.50	Beam nearly standing at .01, with strain of 11.25, but would not stand until torsion reached .023.
		36.80	.797			3 25		37.63	
384	C co 1*	13.75	.01	.004	.006	3 00	.299 x .2969	14.03	
		14.75	.19	.013	.077	1 05		15.05	
		44.77	.501	.484	.017	3 40		45.69	
		46.05	.5875			0 20		47.00	
385	C co 2*	13.80	.01	.004—	.006	3 20	.2075 x .2977	14.11	
		14.80	.0155	.009	.0065	0 40		15.14	
		15.80	.02	.013	.007	1 00		16.16	
		45.45	.500	.484	.016	4 10		46.49	
		47.14	.5985—			0 18		48.22	
386	C co 3*	13.22	.01	.004	.006	2 30	.297 x .2979	13.51	
		14.22	.014	.008	.006	1 20		14.53	
		15.22	.018	.0115	.0065	0 40		15.55	

		44.96	.501	.485	.016	3 15		45.96
		46.29	.579			0 20		47.31
387	C co 4*	13.30	.01	.004	.006	[a]2 20	.3002 x .2998	13.30
		14.30	.014	.008	.006	1 10		14.30
		15.30	.019	.012	.007	0 50		15.30
		46.69	.501	.485	.016	3 20		46.69
		47.95	.591			0 15		47.95
388	C co 5*	13.59	.01	.004	.006	2 05	.297 x .298	13.93
		14.59	.016	.010	.006	1 00		14.96
		45.03	.501	.485	.016	3 05		46.17
		46.60	.589			0 25		47.78
389	C co 6*	14.00	.01	.0045	.0035	3 15	.300 x .300	14.00
		15.00	.016			1 10		15.00
		46.75	.500	.4825	.0175	3 00		46.75
		48.10	.587			0 20		48.10
390	C co 7*	13.82	.01	.004	.006	3 50	.2987 x .2984	14.12
		14.82	.016	.010–	.006	1 35		15.03
		46.43	.501	.484	.017	3 40		47.11
		47.61	.5845			0 13		48.30
391	C co 8*	13.70	.01	.004	.006	3 40	0.300 x 0.3005	13.66
		14.70	.0155	.009	.0065	1 25		14.66
		15.70	.020	.013	.007	2 00		15.66
		46.77	.500	.4835	.0165	3 45		46.65
		47.94	.5725			0 18		47.82
392	C co 9*	13.70	.01	.004	.006	2 35	.2978 x .2979	13.99
		14.70	.019	.012	.007	1 30		15.02
		45.55	.500	.4835	.0165	3 25		46.54
		46.99	.602			0 15		48.01
393	C co 10*	13.85	.01	.004	.006	[a]3 15	.2984 x .2988	14.04
		14.85	.019	.012	.007	2 00		15.05
		47.81	.604			3 40		48.48
394	T co 6 * H L	16.65	.01	.0035	.0065	3 40	.3009 x .3003	16.55
		17.65	.017	.009	.008	1 15		17.54
		18.65	.020	.0125	.0075	1 20		18.53
		55.36	.500	.479	.021	3 50		54.80
		55.36	.5215			0 05		54.80
395	T co 10* H L	17.36	.01	.0035	.0065	3 55	.2996 x .2996	17.42
		18.36	.016	.0085+	.0075	1 20		18.42
		19.36	.019	.012 –	.007	1 10		19.43
		56.86	.486			3 15		57.07

[a] About.

TABLE 26.—*TORSIONAL TESTS of steel gun-wires*—Continued.

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0″ .3 x 0″ .3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
396	T co 6 * CH	20.	.01	.0025	.0075	3 15	.3005 x .3003	19.92	
		21.	.0115	.003 +	.0185	1 00		20.91	
		22.	.013	.0045	.0085	0 35		21.91	
		23.	.0155	.0065+	.0090	1 10		22.91	
		24.	.018	.0085	.0095	1 00		23.90	
		25.	.020	.01 +	.010	1 08		24.90	
		61.09	.407			3 10		60.84	
397	T co 10 * CH	19.05	.01	.003	.007	3 10	.2994 x .2997	19.13	
		20.05	.012	.0045	.0075	1 20		20.13	
		21.05	.015	.007 −	.008	1 10		21.13	
		22.05	.0175	.009 −	.0085	1 15		22.14	
		23.05	.020	.0115	.0085	1 00		23.14	
		59.87	.422			3 00		60.12	
398	T co 9 * CH	20.29	.01	.0025	.0075	4 35	.3007 x .3036	19.85	
		61.69	.3975			3 56		60.38	
399	T co 2 * CH	16.55	.01	.0035	.0065	2 24	.2985 x .2998	16.70	
		53.96	.4375			3 11		54.46	
400	T co 3 * CH	15.23	.01	.0035	.0065	2 20	.300 x .3009	15.22	
		51.52	.468 −			2 43		51.49	
401	T co 4 * CH	20.90	.01	.0025	.0075	2 30	.3035 x .3006	19.47	
		60.96	.3535			4 03		60.79	
402	T co 5 * CH	20.45	.01	.0023	.0077	3 30	.3016 x .3015	20.13	
		61.05	.406			4 30		60.09	
403	T co 7 * CH	17.60	.01	.003 −	.007	2 30	.2996 x .298	17.80	
		56.64	.438			3 10		61.76	
404	T co 8 * CH	19.35	.01	.0025	.0075	2 05	.301 x .3006	19.18	
		62.38	.373			3 35		61.84	

404 *bis.*	D L	19.70	.01	.003	.007	2 57	.302 x .3005	19.53	Annealed in "fresh" turnings.
		20.70	.0115	.004	.0075	1 05	....	20.52	
		21.70	.013	.006 —	.007	0 58	....	21.51	
		22.70	.0155	.007	.0085	1 00	....	22.50	
		23.70	.0175—	.0085	.009	0 54	....	23.49	
		24.70	.195	.010	.0095	0 40	....	24.49	
		63.94	.450	....	....	3 35	....	63.39	
405	D M	16.33	.01	.0035	.0065	2 35	.3005 x .2991	16.36	
		17.33	.0135	.007	.0065	1 05	....	17.46	
		18.33	.0175	.010	.0075	1 15	....	18.36	
		52.79	.502	.4835	.0185	3 43	....	52.89	
		53.72	.569	....	....	0 10	....	53.82	
406	D N	19.42	.01	.0025	.0075	4 45	.2995 x .2986	19.61	
		20.42	.0115	.0035	.008	0 45	....	20.62	
		21.42	.013	.005	.008	0 38	....	21.63	
		22.42	.015	.0065	.0085	0 50	....	22.64	
		23.42	.0175	.008	.0095	0 50	....	23.65	
		24.42	.019	.009	.010	0 34	....	24.66	
		25.42	.0215	.0115	.0100	0 50	....	25.77	
		62.94	.449	....	....	3 18	....	63.56	
407	D O	15.80	.01	.0035	.0065	1 28	.2978 x .2988	16.07	
		16.80	.0115	.006	.0055	0 30	....	17.08	
		17.80	.0155	.008	.0075	0 45	....	18.10	
		18.80	.018	.010	.008	0 44	....	19.12	
		53.93	.501	.480	.021	3 38	....	54.85	
		54.70	.564 —	....	....	0 10	....	55.64	
408	D P	15.30	.01	.0035	.0065	1 45	.300 x .2987	15.39	
		16.30	.015	.007	.008	1 40	....	16.40	
		17.30	.0175	.010	.0075	1 20	....	17.41	
		53.95	.501	.4815	.0195	3 20	....	54.43	
		54.88	.577	....	....	0 30	....	55.23	
409	T co 1 *	17.15	.01	.003+	.007	3 20	.3007 x .3015	16.96	
		18.15	.0125	.006	.0065	1 35	....	17.95	
		19.15	.016	.008	.008	1 15	....	18.93	
		20.15	.0185	.010	.0085	0 55	....	19.92	
		56.90	.4685	....	....	2 58	....	56.97	
410	T co 2*	16.95	.01	.003	.007	3 20	.2976 x .3001	17.14	
		17.95	.0125	.006	.0065	1 00	....	18.15	
		18.95	.0165	.008	.0085	1 11	....	19.16	
		19.95	.0195	.011	.0085	0 55	....	20.19	
		53.03	.4680	....	....	2 50	....	53.65	

† About 2 30.

TABLE 26.—*TORSIONAL TESTS of steel gun-wires*—Continued.

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0″.3 x 0″.3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
411	T co 3*	15.07	.01	.0035	.0065	1 50	.2995 x .301	15.03	Torsion not quite ceased at strain of 15.07.
		16.07	.0155	.008	.0075	1 05		16.02	
		17.07	.0195	.0115	.008	1 00		17.02	
		50.70	.472			3 10		50.57	
412	T co 4*	20.45	.01	.002	.008	2 00	.3018 x .3004	20.22	
		21.45	.512	.004	.008	0 50		21.21	
		22.45	.0175	.0085	.009	1 05		22.20	
		23.45	.021	.012	.0090	1 00		23.19	
		59.44	.378			3 38		58.78	
413	T co 5*	18.33	.01	.0025+	.0075	3 22	.3011 x .3023	18.02	
		59.25	.4215			3 02		58.25	
414	T co 6*	23.90	.01	.0015	.0065	2 50	.300 x .3007	23.81	
		24.90	.0105	.0015	.009	0 40		24.81	
		25.90	.011	.0015+	.0095	0 45		25.80	
		26.90	.0115	.002—	.0095	0 45		26.80	
		27.90	.0115+	.002	.0095	1 00		27.80	
		65.99	.2765			3 05		65.75	
415	T co 7*	16.65	.01	.003	.007	3 35	.2973 x .2994	16.92	
		54.56	.458			3 30		55.47	
416	T co 8*	19.00	.01	.003	.007	3 30	.301 x .2993	18.97	
		57.28	.378			3 10		57.19	
417	T co 9.*	18.79	.01	.003	.007	3 03	.3015 x .3016	18.49	
		60.55	.385			3 40		59.58	
418	T co 10*	18.20	.01	.003	.007	2 53	.2995 x .300	18.24	
		58.82	.419			3 02		58.96	

419	M co 1	13.90 35.59 40.64	.01 .500 .903	.005 .488	.005 .012	2 50 2 40 1 00	.2975 x .2983	14.98 36.33 41.49
420	A co 1	17.94 44.71 48.88	.01 .500 .778	.003 .485	.007 .015	3 00 2 29 0 40	.2979 x .299	18.21 45.40 49.63
421	A co 2	18.92 49.39 52.87	.01 .500 .712+	.003 .4845	.007 .0155	3 52 2 51 0 30	.2972 x .2992	19.26 50.28 53.83
422	A co 3	18. 43.60 48.02	.01 .501. .806	.0035 .4875	.0065 .0135	2 57 2 33 0 55	.299 x .299	18.18 44.05 48.51
423	A co 4	17.66 42.70 46.71	.01 .500 .798	.0035 .487	.0065 .013	2 00 2 45 0 40	.2981 x .2986	17.95 43.41 47.49
424	A co 5	19.70 50.31 53.91	.01 .500 .722	.003— .4835	.007 .0165	2 43 3 12 0 40	.2995 x .2981	19.93 50.89 54.54
425	A co 6	18.62 46.72 50.05	.01 .500 .7235	.003 .485	.007 .015	1 10 2 18 0 25	.298 x .297	19.09 47.90 51.32
426	A co 7	14. 39.79 45.76	.01 .500 .801	.003 .4875	.007 .0125	0 30 2 00 0 58	.2997 x 3002	14.00 39.80 45.78
427	A co 8	17.15 39.22 44.05	.011 .500 .9135	.004 .487	.007 .013	1 15 2 25 0 45	.2987 x .2988	17.35 39.69 44.57
428	A co 9	18.60 46.84 50.30	.01 .500 .719	.0035 .486	.0065 .014	2 10 2 20 0 30	.300 x .3037	18.25 44.98 49.37
429	A co 10	16.46 41.38 45.62	.01 .502 .825	.0035 .488	.0065 .014	†2 25 2 08 0 40	.298 x .298	16.79 42.21 46.54
430	A co 1 *	18.22 45.82 48.48	.01 .500 .667	.003 .486	.007 .014	2 18 2 50 0 30	.2975 x .298	18.63 46.86 49.58

† About.

TABLE 26.—*TORSIONAL TESTS of steel gun-wires*—Continued.

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0".3 x 0".3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m.* *s.*	*Inches.*	*Lbs.*	
431	A co 3*..............	18.70	.01	.0035	.0065	1 40	.299 x .3013	18.67	
		44.80	.500	.4865	.0135	2 15	....	44.73	
		47.95	.701	....	....	0 25	....	47.87	
432	A co 4*..............	16.94	.01	.0035	.0065	1 30	.2965 x .2973	17.47	
		42.88	.500	.4865	.0135	2 01	....	44.28	
		46.62	.725	....	....	0 30	....	48.07	
433	A co 6*..............	18.70	.01	.003	.007	1 40	.2972 x .2978	19.17	
		47.18	.500	.4845	.0155	2 28	....	48.37	
		49.79	.659	....	....	20	....	51.05	
434	A co 8*..............	16.10	.01	.0035	.0065	1 10	.2975 x .2971	16.54	
		38.84	.500	.488 —	.012	2 00	....	39.90	
		42.68	.7915	....	....	0 40	....	43.83	
435	A co 10*..............	42.87	.500	.4865	.0135	2 05	.3005 x .3007	42.59	
		46.35	.728	....	....	0 35	....	46.07	
436	N S co 1*..............	12.55	.01	.005	.005	2 03	.2973 x .2978	12.89	
		36.00	.500	.488	.019	2 00	....	36.90	
		39.78	.7735	....	....	0 33	....	40.70	
437	N S co 2*..............	11.24	.01	.005	.005	1 30	.2979 x .2981	11.46	
		38.80	.500	.486	.014	2 50	....	39.58	
		41.68	.720	....	....	0 27	....	42.52	
438	N S co 3*..............	10.05	.0115	.0075	.0040	2 00	.2969 x .2975	10.34	
		34.37	.500	.489	.011	2 25	....	35.36	
		37.99	.7935	....	....	0 35	....	35.36	
439	N S co 4*..............	10.70	.02	.0155	.0045	3 20	.298 x .2976	10.94	
		34.44	.501	.489	.012	2 37	....	35.21	
		38.05	.8115	....	....	0 43	....	38.90	

440	N S co 5 *	10.00 32.91 36.45	.0185 .500 .858	.0135 .4885	.0050 .0115	4 00 1 55 0 45	.2973 x .2976	10.96 33.04
461	C S co 9 *	18.65 61.95	.01 .361	.0025	.0075	3 00 3 30	.301 x .3015	18.41 61.18
462	C S co 10 *	18.10 58.16	.01 .428	.003	.007	2 15 3 00	.301 x .3008	17.93 58.12
463	C S co 11 *	14.00 48.47 48.47	.01 .500 .524	.004— .482	.006 .018	3 00 2 50 0 05	.2994 x .2992	14.09 48.80 48.80
464	C S co 12 *	18.10 57.54	.01 .384	.003	.007	3 02 3 05	.301 x .301	17.91 56.96
465	C S co 13 *	17.33 53.67	.01 .285	.003	.007	2 00 2 50	.2983 x .3009	17.39 53.86
466	C S co 14 *	15.93 54.68	.01 .417	.003	.007	2 15 3 08	.2998 x .3006	15.79 54.55
467	C S co 15 *	17.68 58.00	.01 .406	.003	.007	2 45 2 45	.301 x .301	17.48 57.35
468	C S co 16 *	15.62 53.36	.01 .4505	.003+	.007	2 00 2 45	.2976 x .2989	15.89 54.30
469	C S co 17 *	17.45 58.14	.01 .406	.003	.007	2 30 2 32	.299 x .302	17.39 57.85
470	C S co 18*	15.35 52.66	.01 .472	.0035	.0065	1 00 2 25	.3007 x .3007	15.24 52.29
471	H W co 8	20.40 62.80	.01 .4315	.0025	.0075	3 50 3 50	.301 x .3017	20.12 61.94
472	H W co 9	14.35 49.43 51.53	.01 .501 .6215	.003+ .479	.007 .022	1 30 2 32 0 12	.2984 x .2985	14.57 50.20 52.33
473	H W co 10	19.68 61.55	.01 .442	.0025	.0075	2 40 3 12	.298 x .2982	20.06 62.75
474	H W co 11	15.73 51.94 53.	.01 .500 .582	.003+ .479	.007 .021	2 52 2 47 0 15	.2981 x .2982	16.01 52.67 53.95
475	H W co 12	16.45 53.58 54.36	.01 .502 .5725	.003 .4795	.07 .225	1 30 2 55 0 10	.299 x .300	16.53 53.85 54.63

TABLE 26.—*TORSIONAL TESTS of steel gun-wires*—Continued.

Mark on specimen designating.		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0″ .3 x 0″ .3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
476	N S co 1	12.50	.01	.004	.006	2 15	.2978 x .297	12.82	
		34.71	.500	.488	.012	2 05	....	35.61	
		38.35	.790	....	....	0 34	....	39.34	
477	N S co 2	11.25	.01	.0045	.0055	1 58	.2983 x .297	11.51	
		37.67	.501	.4875	.0135	2 27	....	38.56	
		50.96	.755	....	....	0 33	....	41.93	
478	N S co 3	10.10	.01	.006	.004	2 00	.2985 x .296	10.38	
		33.63	.501	.4885	.0125	2 20	....	34.57	
		37.43	.825	....	....	0 36	....	38.47	
479	N S co 4	10.	.012	.0075	.0045	2 15	.297 x .298	10.25	
		33.77	.500	.487	.013	2 00	....	34.62	
		37.58	.801	....	....	0 28	....	38.53	
480	N S co 5	10.	.0215	.0175	.0040	3 10	.2974 x .2971	10.28	The 10 pounds were raised before the torsion reached 0.01, but torsion continued with the same strain until it reached 0.0215.
		31.70	.501	.4885	.0125	1 40	....	32.58	
		35.82	.868	....	....	0 39	....	36.82	
486	B S co * 1	12.	.034	.0285	.0055	2 45	.2959 x .2944	12.60	Both these specimens raised 12 pounds before reaching a torsion of 0.01, but the torsion continued to the extent given, in the times specified.
		31.10	.499	.488	.011	2 15	....	32.65	
		35.31	.904	....	....	1 10	....	37.07	
487	B S co *1	12.	.0365	.030	.0065	2 50	.2945 x .2962	12.57	
		31.05	.501	.489	.012	2 23	....	32.54	
		35.52	.889	....	....	0 55	....	37.32	
488	B S co 1 *	10.	.025	.020	.005	2 20	.2953 x .2953	10.48	Behaved like Nos. 486 and 487.
		30.15	.501	.490	.011	2 45	....	31.61	
		34.40	.8885	....	....	0 57	....	36.04	
489	A S co *	16.45	.01 +	.003 +	.007	2 00	.2965 x .2964	17.03	Tool-steel, (Aultman Steel Company.)
		52.	.385	....	....	3 35	....	53.85	

490	C co 16 *	17. 32 56. 94 57. 00	. 01 . 501 . 5285	. 003 . 477	. 007 . 024	2 40 3 10 0 10	. 2967 x . 2947	18. 07 59. 43 59. 49	
491	C co 17 *	16. 35 55. 87	. 01 . 446	. 0035–	. 0065	2 25 2 36	. 299 x . 2984	16. 56 56. 60	
492	C co 18 *	16. 21 56. 09	. 01 . 4515	. 003 +	. 007	3 05 3 52	. 2975 x . 2985	16. 53 57. 22	
493	C co 19 *	15. 72 55. 45	. 01 . 465	. 003	. 007	2 12 3 12	 . 298 x . 2978	16. 05 56. 63	
494	C co 20 *	16. 20 56. 53	. 01 . 480	. 003	. 007	2 20 3 38	. 2981 x . 2981	16. 51 57. 63	
495	C co 11 *	16. 34 56. 89	. 01 . 481	. 003 +	. 007	2 50 3 00	. 2978 x . 2978	17. 27 58. 17	
496	C co 12 *	16. 27 56. 85	. 01 . 4695	. 003	. 007	3 00 3 51	. 2986 x . 2996	16. 42 57. 38	
497	C co 13 *	16. 50 56. 00	. 01 . 436	. 003	. 007	3 30 2 53	. 2974 x . 2979	16. 89 58. 33	
498	C co 14 *	16. 03 56. 11	. 01 . 465	. 003	. 007	1 20 3 33	. 2979 x . 2982	16. 34 57. 21	
499	C co 15 *	16. 60 56. 81	. 01 . 466	. 003	. 007	2 05 3 47	. 298 x . 2979	16. 94 58. 08	
501	A co 1 *	19. 20 46. 98 50. 00	. 01 . 501 . 6835	. 003 – . 484	. 007 . 017	3 15 2 43 0 24	. 2973 x . 2967	19. 78 48. 31 51. 53	
508	B S co 2 *	10. 00 30. 55 35. 04	. 0115 . 499 . 91 +	. 007 . 488	. 0045 . 011	2 05 1 57 0 45	. 295 x . 295	10. 50 32. 08 36. 79	
509	B S co 2 *	10. 00 30. 56 34. 83	. 01 . 500 . 918	. 0055 . 489	. 0045 . 011	4 20 1 57 0 42	. 295 x . 295	10. 50 32. 09 36. 57	
510	H co 1 *	17. 25 49. 17	. 01 . 404	. 0025+	. 0075	3 46 1 50	. 295 x . 295	18. 11 51. 63	
511	H co 1 *	16. 00 43. 88	. 015 . 316	. 0065	. 0085	2 50 2 05	. 2952 x . 2952	16. 78 45. 02	
512	B S co 2 *	10. 49 31. 15 35. 07	. 026 . 501 . 8435	. 021 . 490	. 005 . 011	3 45 2 33 0 38	. 2955 x . 2.52	10. 99 32. 64 36. 75	10. 49 pounds were raised before torsion reached 0. 01.

TABLE 26.—*TORSIONAL TESTS of steel gun-wires*—Continued.

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0″.3 x 0″.3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
513	B S co 2*	10.00	.022	.0175	.0045	3 50	.2952 x .2951	10.50	10.00 pounds were raised before torsion reached 0.01.
		30.68	.500	.4885	.0115	2 23		32.21	
		34.82	.864			0 40		36.50	
514	N S co 8 *	13.00	.021	.0155	.0055	4 40	.2956 x .2955	13.59	
		37.04	.500	.487	.013	2 14		38.72	
		41.00	.787			0 44		42.86	
515	N S co 8*	12.50	.01	.0045	.0055	3 30	.2957 x .2955	13.05	
		13.00	.021	.0155	.0055	2 50		13.57	
		36.98	.501 +	.487	.014	2 48		38.32	
		40.66	.769			0 40		42.47	
516	B S co 3*	10.20	.028	.022	.006	*3 50	.2955 x .2955	10.67	10.20 pounds were raised before torsion reached 0.01.
		30.00	.502	.490	.012	1 56		31.38	
		34.21	.899			0 50		35.79	
517	B S co 3*	10.21	.027	.0215	.0055	1 20	.2953 x .296	10.62	10.21 pounds were raised before torsion reached 0.01.
		30.25	.5025	.4915	.0110	0 34		31.47	
		34.39	.907			4 48		35.78	
518	H co 2 *	16.90	.01	.003	.007	2 30	.297 x .2973	17.45	
		43.85	.200	.179	.021	2 04		45.12	
		47.11	.301	.279	.022	0 28		48.48	
		47.49	.331			0 05		48.87	
519	N S co 6 *	18.65	.01	.0025	.0075	2 30	.298 x .2978	19.04	
		51.82	.200	.1765	.0235	1 45		52.90	
		55.79	.300	.274	.026	0 27		56.96	
		57.68	.37 +			0 15		58.89	
520	N S co 6 *	18.01	.01	.003 −	.007	1 08			
		51.74	.200	.1765	.0235	1 50			
		55.77	.300	.2745	.0255	0 24			
		58.02	.379			0 16			

521	N S co 7*	16.25 44.14 49.50 50.40	0.01 .300 .501 .564	.003 .281 .4815 (Broke.)	.007 .019 .0195	2 00 2 18 0 38 0 16	.2971 x .2968	16.67 45.28 50.78 51.71	
522	N S co 7*	16.00 48.76 49.94	.01 .591 .571	.003 + .480 (Broke.)	.007 .021	1 00 2 50 0 18	.2965 x .297	16.52 50.35 51.57	
532	A co 11 H L *	22.40 53.84 55.98	.01 .500 .646	.0015 .480 + (Broke.)	.0085 .020	*4 00 2 36 0 21	.2989 x .2971	22.85 54.92 57.11	Annealed together.
533	A co 11 H L *	22.15 54.40 56.00	.01 .500 .600	.0015 + .480 (Broke.)	.0085 .020	3 45 2 44 0 30	.2994 x .297	22.55 55.40 57.03	
534	A co 11 H L *	21.93 55.89 56.02	.01 .60 .628	.002 .581 (Broke.)	.008 .019	35 7 31 0 0 8	.299 x .297	22.37 57.01 57.15	Annealed together.
535	A co 11 H L *	21.48 53.78 54.82	.01 .503 .579	.002 .482 (Broke.)	.008 .021	1 08 2 30 0 15	.2951 x .2983	22.18 55.55 56.62	
536	N S co 9 H L *	14.00 40.82 43.83	.01 .501 .735	.004 .4857 (Broke.)	.006 .0153	2 00 2 20 0 35	.2961 x .2964	14.53 42.39 46.51	Nearly standing in two minutes.
537	N S co 10 H L *	15.13 45.86 46.86	.01 .503 .569	.0035 .484 — (Broke.)	.0065 .019	2 10 3 00 0 13	.2958 x .2954	15.80 47.90 48.94	Nearly standing.
538	N S co 11 H L *	14.00 41.17 43.62	.01 .501 .676	.004 — .485 + (Broke.)	.006 .016	1 20 2 28 0 28	.297 x .296	14.48 42.59 45.12	Nearly standing.
539	N S co 12 H L *	14.50 44.30 46.32	.01 .501 .6355	.004 — .485 (Broke.)	.006 .016	1 31 2 30 0 25	.295 x .2958	15.18 46.39 48.51	Nearly standing.
540	A co 11 *	21.10 55.61	.01 .5135	.0025— (Broke.)	.0075	2 35 2 45	.298 x .297	21.63 57.02	
541	A co 11 *	20.85 55.88 56.14	.01 .501 .526	.002 + .4815 (Broke.)	.008 .0195	2 30 2 37 0 5	.2985 x .2967	21.34 57.21 57.47	
542	N S co 9 *	13.34 40.93 43.46	.01 .501 .701 +	.004 .486 + (Broke.)	.006 .015	1 45 2 05 0 31	.2957 x .2959	13.84 42.53 45.16	

* About.

TABLE 26.—*TORSIONAL TESTS of steel gun-wires*—Continued.

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0″.3 x 0″.3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
543	N S co 10 ✱	15.00 46.22 47.77	.01 .502 .6015	.0035 .484 (Broke.)	.0065 .018	2 40 2 27 0 15	.2952 x .2951	15.75 48.53 50.16	Nearly standing.
544	N S co 11 ✱	13.38 41.25 43.68	.01 .501 .662	.004 .485 (Broke.)	.006 .016	1 15 2 05 0 23	.2964 x .296	13.90 42.86 45.39	
545	N S co 12 ✱	14.49 44.75 46.51	.01 .502 .605	.0035 .485 (Broke.)	.0065 .017	1 45 2 14 0 15	.2951 x .2958	15.16 46.83 48.67	
546	T co 11 ✱	18.86 54.83	.01 .388−	.003 − (Broke.)	.007	2 20 2 00	.3013 x .3007	18.41 54.28	
547	T co 11 ✱	18.50 54.00	.01 .4125	.003 − (Broke.)	.007	2 15 2 20	.3009 x .3005	18.37 53.62	
548	T co 12 ✱	18.11 53.00	.01 .4175	.0025 (Broke.)	.0075	2 30 2 05	.2987 x .2981	18.40 53.85	
549	T co 12 ✱	18.45 53.72	.01 .4205	.0025+ (Broke.)	.0075	2 30 2 50	.2991 x .2983	18.69 54.41	
550	T co 13 ✱	19.08 54.75	.01 .3755	.0025+ (Broke.)	.0075	2 55 2 10	.3007 x .3005	18.96 54.42	
551	T co 13 ✱	19.07 55.83	.01 .3835	.0025+ (Broke.)	.0075	2 20 2 10	.300 x .3008	18.99 55.60	
552	T co 14 ✱	18.90 52.65	.0125 .376 +	.... (Broke.)	....	2 15 2 00	.298 x .2985	19.23 53.58	

553	T co 14*	18.45 54.10	.01 .406	.003 (Broke.)	.007	2 40 2 01	.2986 x .2981	18.75 55.60	
554	T co 15 *	17.95 58.00	.01 .395	.003 — (Broke.)	.007	2 00 2 10	.299 x .3002	18.00 58.19	
555	T co 15 *	18.76 50.88 53.77	.01 .3015 .423 +	.0025+ .2805— (Broke.)	.0075 .0210	2 25 1 58 0 27	.3002 x .2991	18.82 51.04 53.94	
556	T co 16 *	18.45 50.10 53.42	.01 .302 .419	.0025+ .2835 (Broke.)	.0075 .0185	2 45 1 42 0 21	.2978 x .2972	18.88 51.27 54.67	
557	T co 16 *	18.45 50.60 53.88	.0105 .300 .4195	.003 .279 (Broke.)	.007 .021	2 10 1 58 0 18	.2981 x .299	18.71 50.83 54.66	
561	T co 11 *	20.70 56.21 58.65	.01 .301 .377	.002 + .278 + (Broke.)	.008 .023	3 01 2 48 0 19	.3003 x .301	20.56 55.84 58.27	
562	T co 12 *	20.00 54.75 56.37	.01 .300 .3625	.002 + .2775 (Broke.)	.008 .0225	3 50 2 21 0 16	.2989 x .2983	20.28 55.51 57.16	
563	T co 13 *	20.98 56.89 58.62	.01 .303 .362	.002 + .278 (Broke.)	.008 .025	1 45 2 06 0 10	.3005 x .2996	20.96 56.86 58.59	
564	T co 14 *	20.00 55.08 57.08	.01 .302 .379	.002 .278 (Broke.)	.008 .024	1 30 2 51 0 15	.2978 x .2981	20.41 26.22 58.26	
565	T co 15 *	20.41 55.57 56.46	.01 .302 .339	.0025 .278 (Broke.)	.0075 .024	2 01 2 54 0 9	.300 x .299	20.51 55.84 56.74	
566	T co 16*	19.75 54.62 56.00	.01 .301 .3635	.002 .278 + (Broke.)	.008 .023	1 10 2 20 0 16	.2973 x .2983	20.19 55.84 57.26	
567	B S co 2*	10.45 .... 30.97 35.01	.... .0245 .500 .863	.... .019 .488 (Broke.)	.... .0055 .012	(?) 6 04 3 13 0 43	.... .2948 x .2951	10.99 .... 32.58 36.83	Nos. 567 and 568 annealed side by side, standard heat. Continued to yield 6 04 without increased strain.
568	B S co 4	10.00 10.10 29.49 34.83	.... .0285 .501 1.0775	.... .0235 .490 (Broke.)	.... .0050 .011	.... 6 00 2 01 1 07	....	....	Began to yield at 10 pounds, slowly, and nearly stood at 0.007.

TABLE 26.—*TORSIONAL TESTS of steel gun-wires*—Continued.

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0″.3 x 0″.3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
569	E F* (C H co)........	14.65	0.01	.0035+	.0065	2 40	.2957 x .297	15.19	
		35.03	.502	.489	.013	2 14	....	36.33	
		40.00	.875 +	(Broke.)	....	1 05	....	41.49	
570	E F* (C H co)........	13.46	.01	.0035	.0065	1 32	2952 x 2973	13.88	
		33.30	.499	.4875	.0015	2 06	....	34.34	
		39.80	.874	(Broke.)	....	0 50	....	41.04	
572	C H co Spr. *........	21.00	.01	.0015+	.0085	4 29	.2965 x .2953	21.88	
	G 1.1 (una'd)..........	36.89	.501	.4867	.0143	2 03	....	38.44	
		38.90	.9275	(Broke.)	....	1 01	....	40.53	
573	C H co Spr *.........	21.03	.01	.0015+	.0085	2 33	.2954 x .2947	22.10	
	G 3.1 (una'd)..........	36.63	.5025	.4875	.0150	2 06	....	38.50	
		38.77	1.0645	(Broke.)	....	1 15	....	40.75	
575	C H co Spr *.........	11.50	.013	.007	.006	3 02	.2956 x .2973	11.79	Specimens Nos. 575 to 580, inclusive, were annealed together at standard heat.
	G 1.1 H...............	28.60	.501	.4895	.0115	2 01	....	29.32	
	L	34.47	.854 —	(Broke.)	....	0 46	....	35.34	
576	C H co Spr *	12.94	.0425	.037 +	.0055	4 45	.294 x .2938	13.76	With strain of 12.94 pounds torsion nearly ceased at .007, but suddenly increased and became .0425.
	G 1.2 H...............	30.05	.503	.4925	.0105	1 53	....	31.97	
	L	34.56	.951	(Broke.)	....	0 55	....	36.76	
577	C H co Spr ⁘.........	13.75	.0435—	.0375	.006	4 40	.2949 x .2953	14.44	With strain of 13.75 pounds torsion nearly ceased at .009, (in 2 minutes 45 seconds,) but suddenly increased and became .0435, (in 4 minutes and 40 seconds.)
	G 2.1 H...............	30.92	.501	.489	.012	1 58	....	32.48	
	L	35.31	.924 —	(Broke.)	....	0 45	....	37.09	
578	C H co Spr *	13.88	.044	.038	.006	5 20	.2955 x .2947	14.65	With strain of 13.88 pounds, (after 3 minutes and 20 seconds,) apparently stood a few moments at torsion of .009, and suddenly yielded, going to .044.
	G 2.2 H...............	31.09	.512	.50 +	.012	1 40	....	32.83	
	L	35.20	.894	(Broke.)	....	0 46	....	37.23	

579	C H co SPR *	12.51	.035	.025	.010	5 40	.295 x .2955	13.13	Torsion nearly ceased at .009, but suddenly increased.
	G 3.1 H L	29.96	.501	.4905	.0105	1 57		31.44	
		34.64	.960	(Broke.)		1 00		36.32	
580	C H co SPR *	12.53	.034	.0285	.0055	5 40	.295 x .295	13.27	Torsion nearly ceased before reaching .01, but suddenly increased.
	G 3.2 H L	30.03	.500	.489	.011	2 00		31.81	
		34.90	.955	(Broke.)		0 47		36.97	
581	M co 2 * (UNA'D)	21.44	.01	.0015	.0087	3 12	.2961 x .2981	21.99	
		49.17	.501	.483	.018	2 32		50.62	
		49.34	.529	(Broke.)		0 03		50.79	
582	M co 2 *	16.75	.025	.018	.007	18 27	.2957 x .2972	17.17	Torsion reached .01 (with 16.75 pounds) in 2 minutes 30 seconds.
		40.37	.500	.486	.014	2 24		41.39	
		43.47	.738	(Broke.)		0 31		44.59	
583	M co 2 *	16.45	.01	.003 +	.007	5 12	.296 x .2974	16.88	Torsion not absolutely ceased at .01.
		40.63	.502	.4885	.0135	2 30		41.71	
		43.48	.708	(Broke.)		0 30		44.64	
584	M co 3 *	20.85	.01	.002	.008	3 50	.299 x .2998	20.97	
		63.32	.3655	(Broke.)		3 08		63.70	
585	M co 3	21.08	.01	.002	.008	4 12	.2996 x .299	21.22	
		55.70	.200	.1775–	.0225	2 33		56.08	
		63.64	.3835	(Broke.)		0 41		64.08	
586	M co 1 *	14.60	.01	.004	.006	2 30	.3015 x .3002	14.47	
		38.98	.500	.489	.011	2 05		38.65	
		42.57	.756	(Broke.)		0 32		42.21	
587	M co 1 *	14.57	.01	.004	.006	2 40	.3013 x .300	14.46	
		38.83	.501	.4885	.0125	2 17		38.57	
		42.81	.7775	(Broke.)		0 29		42.53	
588	M co 2 *	15.95	.01	.0035	.0065	†13 00	.297 x .298	16.35	
		39.90	.5005	.487	.0135	1 55		40.91	
		43.32	.730	(Broke.)		0 27		44.42	
589	M co 2 *	16.55	.0325	.026	.0065	1 30	.296 x .2978	16.93	16.55 pounds raised before torsion reached .01—continued to .032.
		39.81	.501	.4875	.0135	1 52		40.79	
		43.42	.740	(Broke.)		0 30		44.49	
590	M co 3 *	21.51	.01	.0025	.0075	3 10	.2989 x .2996	21.63	
		60.60	.300	.2765+	.0235	3 00		60.76	
		63.93	.407	(Broke.)		0 18		64.31	
591	M co 3 *	21.15	.01	.002–	.008	2 35	.2987 x .2998	21.27	
		60.70	.300	.2745	.0255	3 05		71.06	
		64.00	.413	(Broke.)		0 25		64.38	

† About.

TABLE 26.—*TORSIONAL TESTS of steel gun-wires*—Continued.

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0″.3 x 0″.3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
592	A co 12 *	19.63	.01	.003	.007	3 15	.2967 x .2984	20.12	
		46.16	.301	.285	.016	2 00		47.31	
		51.69	.502	.4855	.0165	0 50		52.98	
		52.43	.533	(Broke.)		0 7		53.74	
593	A co 13 *	21.43	.01	.0025	.0075	2 50	.296 x .297	22.19	
		47.54	.300	.2835	.0165	1 46		49.24	
		53.00	.472	(Broke.)		0 30		54.89	
594	A co 14 *	19.70	.01	.003	.007	2 30	.2961 x .2982	20.47	
		41.49	.301	.2885	.0125	1 32		42.69	
		46.94	.502	.4875	.0145	0 38		48.30	
		48.33	.590	(Broke.)		0 14		49.73	
595	A co 15 *	19.30	.01	.003	.007	3 10	.2975 x .2961	19.93	
		47.24	.520	.505	.015	1 41		48.78	
		48.80	.606	(Broke.)		0 12		40.39	
596	A co 16 *	20.11	.01	.003	.007	2 30	.297 x .2968	20.60	
		46.70	.300	.286	.014	1 58		47.85	
		51.83	.503	.488	.015	0 30		53.11	Did not again lift the weight; ultimate torsion not obtained.
597	A co 17 *	20.35	.0105	.0035	.0070	2 45	.2974 x .2963	20.99	
		47.54	.500	.485	.015	2 00		49.05	
		48.80	.579	(Broke.)		0 10		50.35	
598	A co 18 *	19.79	.01	.003	.007	2 40	.297 x .2977	20.31	
		49.38	.501	.485	.016	2 00		52.51	
		50.62	.5815	(Broke.)		0 10		51.98	
599	A co 19 *	19.22	.01	.003	.007	1 35	.298 x .2973	19.66	
		45.68	.502	.488	.014	2 24		46.74	
		47.38	.6145	(Broke.)		0 13		48.48	

600	A co 20 *............	20. 68 47. 64 52. 94	.01 .301 .490	.0025 .2855 (Broke.)	.0075 .0155	2 33 1 48 0 45	.2976 x .2977	21. 17 48. 77 54. 19
601	A co 21 *............	19. 50 46. 88 48. 79	.01 .502 .624	.003 + .4875 (Broke.)	.007 .0145	2 07 1 50 0 18	.297 x .2971	20. 08 48. 29 50. 26
602	A co 22 *............	22. 70 56. 73 61. 78	.01 .300 .4575	.002 .280 (Broke.)	.008 .020	2 20 1 59 0 26	.2985 x .2986	23. 03 57. 55 62. 68
603	A co 23 *............	19. 90 46. 21 47. 87	.013 .502 .598	.0065 .487 (Broke.)	.0065 .015	2 00 1 49 0 10	.2985 x .298	20. 25 47. 02 48. 70
604	A co 24 *............	18. 50 45. 14 47. 03	.0115 .508 .6305	.0055 .492 (Broke.)	.0060 .016	2 20 1 47 0 18	.2985 x .298	18. 82 45. 93 48. 16
605	A co 25 *............	18. 40 44. 53 46. 90	.011 .501 .656	.004 – .487 – (Broke.)	.007 .014	2 05 1 49 0 17	.2986 x .298	18. 71 45. 29 47. 70
606	A co 26 *............	17. 95 43. 80 45. 82	.01 .502 .623	.0035 .488 (Broke.)	.0065 .014	1 27 1 37 0 17	.2989 x .2978	18. 24 44. 53 46. 58
607	A co 27 *............	18. 80 46. 78 48. 25	.01 .501 .591	.0035 .486 (Broke.)	.0065 .015	2 43 1 57 0 10	.2983 x .2985	19. 10 47. 53 49. 02
608	A co 28 *............	18. 74 45. 78 48. 15	.01 .502 .648	.003 .4865 (Broke.)	.007 .0155	1 57 1 51 0 18	.2981 x .299	19. 01 46. 44 48. 85
609	A co 29 *............	19. 25 45. 39 46. 37	.01 .512 .580	.0035 .495 (Broke.)	.0065 .017	2 27 1 55 0 10	.298 x .298	19. 63 46. 30 47. 40
610	A co 30 *............	18. 90 46. 19 47. 68	.011 .500 .580	.004 .486 (Broke.)	.007 .014	2 30 1 52 0 13	.2981 x .2986	19. 21 46. 96 48. 47
611	A co 31 *............	18. 50 44. 70 47. 18	.011 .500 .6555	.005 .487 (Broke.)	.006 .013	2 00 1 02 0 20	.2981 x .299	18. 83 45. 52 48. 04
612	A co 32 *............	19. 00 46. 69 48. 74	.01 .502 .6255	.003 + .488 (Broke.)	.007 .014	2 30 1 48 0 17	.2986 x .2981	19. 31 47. 46 49. 55

TABLE 26.—*TORSIONAL TESTS of steel gun-wires*—Continued.

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0''.3 x 0''.3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
613	A co 33 *	20.51	.01	.0025	.0075	2 30	.2986 x .299	20.74	
		54.20	.451	.433	.018	2 38		54.83	
		54.98	.479	(Broke.)		0 07		55.62	
614	A co 34 *	21.75	.01	.0025	.0075	3 30	.2997 x .299	21.89	
		54.16	.300	.2825	.0175	1 56		54.51	
		58.85	.4645	(Broke.)		0 23		59.23	
615	A co 35 *	22.60	.01	.0025	.0075	2 07	.2999 x .2993	22.68	
		57.17	.299	.279	.020	2 28		57.37	
		61.00	.405	(Broke.)		0 25		61.22	
616	A co 36 *	21.90	.01	.0025	.0075	2 20	.299 x .2994	22.07	
		54.85	.300	.285	.015	2 00		55.30	
		58.86	.4275	(Broke.)		0 21		59.34	
617	A co 37 *	20.95	.01	.0025	.0075	2 48	.2998 x .2989	21.18	
		52.40	.300	.283	.017	2 13		52.74	
		57.83	.489	(Broke.)		0 35		58.20	
618	A co 38 *	19.51	.01	.003	.007	1 45	.299 x .2995	19.64	
		48.02	.300	.2825	.0175	1 48		48.36	
		54.31	.514	(Broke.)		0 23		54.69	
619	A co 39 *	21.95	.01	.0025	.0075	1 45	.299 x .2997	22.09	
		53.48	.301	.282	.019	2 01		53.82	
		58.43	.466	(Broke.)		0 27		58.80	
620	A co 40 *	21.48	.01	.002	.008	1 26	.299 x .2997	21.61	
		55.21	.299	.279	.020	2 02		55.56	
		59.29	.4275	(Broke.)		0 20		59.67	
621	A co 41 *	21.49	.0105	.0025	.0080	1 55	.299 x .2995	21.64	21.45 pounds raised before torsion of 0.01 was reached.
		52.68	.300	.280	.020	1 54		53.05	
		57.97	.468	(Broke.)		0 25		58.38	

622	C H co 6*	11. 92	.01	0. 0035+	.0065	3 20	.2989 x .2993	12. 15	A seam on one side.
		33. 15	.521	.508	.013	1 38	....	33. 80	
		36. 19	.660	(Broke.)	....	0 18	....	36. 90	
623	C H co 7*	14. 78	.01	.0045	.0055	3 00	.2982 x .2985	15. 77	A seam.
		36. 10	.503	.491	.012	1 40	....	38. 52	
		38. 82	.702	(Broke.)	....	0 23	....	40. 42	
624	C H co 8 *............	12. 70	.01	.0035+	.0065	2 10	.2986 x .299	12. 84	
		34. 51	.499	.488 +	.011	2 00	....	34. 91	
		38. 70	.711	(Broke.)	....	0 25	....	39. 15	Seams.
625	C H co 9*............	12. 20	.01	.004	.006	2 40	.2983 x .299	12. 36	
		33. 90	.501	.490	.010	1 40	....	34. 36	
		38. 00	.783	(Broke.)	....	0 31	....	38. 51	Seams on three sides.
626	H W co 13*	14. 65	.0155	.009	.0065	1 55	.2992 x .2982	14. 84	14. 65 pounds were raised before torsion of 0. 01 was reached, but torsion became .0155.
		43. 50	.501	.4885	.0165	1 56	....	44. 06	
		44. 00	.556	(Broke.)	....	0 07	....	44. 57	
627	H W co 14 *..........	13. 90	.011	.006	.005	5 52	.2997 x .299	13. 99	13. 90 pounds were lifted before reaching torsion of 0. 01.
		43. 05	.500	.4865	.0135	2 12	....	43. 32	
		43. 52	.548	(Broke.)	....	0 05	....	43. 80	
628	H W co 15 *..........	13. 88	.01	.004	.006	2 30	.2976 x .297	14. 26	
		43. 17	.502	.486	.018	2 02	....	44. 35	
		43. 71	.547	(Broke.)	....	0 06	....	44. 91	
629	H W co 16 *..........	14. 51	.01	.004 −	.006	2 10	.2984 x .3001	14. 61	
		44. 44	.501	.485	.016	2 05	....	44. 75	
		44. 62	.5485	(Broke.)	....	0 03	....	44. 93	
630	H W co 17 *..........	14. 40	.012	.0065	.0055	2 30	.300 x .2983	14. 53	14. 40 pounds were raised before reaching torsion of 0. 01.
		43. 79	.500	.483	.017	2 00	....	44. 19	
		44. 80	.5695	(Broke.)	....	0 08	....	45. 21	
631	H W co 18 *..........	14. 34	.015	.0085	.0065	4 10	.297 x .2979	14. 76	14. 34 pounds raised before reaching torsion of 0. 01.
		43. 13	.500	.486	.014	2 22	....	44. 41	
		43. 73	.543	(Broke.)	....	0 05	....	45. 03	
632	H W co 19*	14. 17	.01	0. 004 −	.006	2 18	.2983 x .300	14. 30	
		43. 93	.502	.486	.016	2 01	....	44. 33	
		44. 24	.541	(Broke.)	....	0 06	....	44. 65	
633	H W co 20*	14. 21	.01	.004 −	.006	1 40	.2976 x .2973	14. 57	
		43. 83	.503	.4885	.0145	1 53	....	44. 96	
		44. 14	.559	(Broke.)	....	0 06	....	45. 28	
634	A co 17*	19. 40	.01	.003 +	.007	3 20	.2970 x .2971	19. 98	
		45. 00	.500	.486 −	.014	1 45	....	46. 35	
		48. 14	.716	(Broke.)	....	0 23	....	49. 58	

TABLE 26.—*TORSIONAL TESTS of steel gun-wires*—Continued.

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0″.3 x 0″.3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
635	A co 18*	20.55	.01	.003	.007	2 32	.2976 x .2974	21.15	
		48.43	.501	.4855	.0155	2 01		49.84	
		50.73	.663	(Broke.)		0 21		52.20	
636	A co 19*	18.98	.01	.003	.007	2 00	.2976 x .2975	19.52	
		44.43	.500	.486 −	.014	1 50		45.70	
		47.15	.702	(Broke.)		0 24		48.50	
637	A co 20*	21.53	.01	.003 −	.007	2 20	.2978 x .2977	22.03	
		51.63	.502	.485 +	.017	2 04		52.80	
		53.42	.6175	(Broke.)		0 12		54.63	
638	A co 21*	18.67	.01	.003 +	.007	2 00	.2975 x .2974	19.15	
		45.30	.501	.4865	.0145	1 40		46.47	
		48.26	.702	(Broke.)		0 20		49.51	
639	A co 22*	22.78	.01	.0025	.0075	2 02	.299 x .2986	23.05	
		50.40	.400	.380	.020	1 18		51.00	
		61.31	.502	.482	.020	0 20		62.05	
		61.97	.535	(Broke.)		05		62.71	
640	A co 23*	18.09	.01	.0035	.0065	1 30	.2985 x .2984	18.44	
		43.83	.501	.488	.013	1 43		44.68	
		46.68	.689	(Broke.)		0 22		47.58	
641	A co 24*	18.00	.028	.021	.007	4 00	.2986 x .2982	18.28	18 pounds raised before torsion of 0.01 was reached.
		43.28	.540	.528 −	.012	2 07		43.97	
		45.89	.736	(Broke.)		0 28		46.62	
642	A co 25*	17.70	.01	.003 +	.007	2 40	.299 x .2982	17.94	
		43.38	.510	.497	.013	1 53		43.89	
		46.68	.719	(Broke.)		0 25		47.33	

643	A co 26 *	17. 50 42. 21 45. 35	. 011 . 501 . 6995	. 005 . 487 (Broke.)	. 006 . 014	3 30 2 12 0 31	. 2987 x . 298	17. 70 42. 91 46. 10	17.50 pounds raised before torsion of 0.01 was reached.
644	A co 27 *	17. 60 44. 08 47. 35	. 01 . 503 . 7205	. 0035 . 489 (Broke.)	. 0065 . 014	2 00 1 30 0 31	. 2985 x . 2983	18. 08 44. 78 48. 11	
645	A co 28 *	18. 23 44. 43 47. 45	. 01 . 500 . 715	. 0035 . 4865 (Broke.)	. 0065 . 0135	2 50 2 12 0 21	. 2982 x . 299	18. 48 45. 45 48. 01	
646	A co 29 *	18. 07 43. 20 46. 12	. 01 . 502 . 715	. 003 . 4895 (Broke.)	. 007 . 0125	3 07 1 20 0 26	. 2988 x . 298	18. 36 43. 89 46. 86	
647	A co 30 *	18. 41 44. 69 47. 67	. 01 . 500 . 681	. 0035 . 4865 (Broke.)	. 0065 . 0135	2 55 1 53 0 20	. 2989 x . 2983	18. 66 45. 32 48. 34	
648	A co 31 *	18. 00 43. 30 46. 45	. 01 . 500 . 722	. 0035 . 486 (Broke.)	. 0065 . 014	2 25 1 42 0 27	. 2981 x . 2989	18. 47 44. 45 47. 68	
649	A co 32 *	18. 60 44. 44 47. 90	. 011 . 501 . 7155	. 005 . 4865 (Broke.)	. 006 . 0145	2 40 1 44 0 23	. 299 x . 2984	18. 84 45. 02 48. 51	18.60 pounds raised before torsion of 0.01 was reached.
650	A co 33 *	20. 80 53. 49 54. 50	. 01 . 501 . 575 —	. 003 . 483 (Broke.)	. 007 . 018	2 50 1 40 0 21	. 299 x . 2997	20. 93 53. 83 54. 84	
651	A co 34 *	22. 40 57. 81 58. 05	. 01 . 501 . 526	. 0025 . 482 - (Broke.)	0075 019	2 00 2 33 0 06	. 2991 x . 2997	22. 64 58. 21 58. 42	
652	A co 35 *	22. 15 49. 51	. 01 . 466	. 0025 (Broke.)	. 0075	3 00 2 10	. 2997 x . 2994	22. 24 49. 73	
653	A co 36 *	22. 28 55. 35 58. 38	. 01 . 401 . 5105	. 0025 . 381 (Broke.)	. 0075 . 020	2 00 2 40 0 17	. 2953 x . 2955	23. 33 57. 97 61. 14	
654	A co 37 *	21. 80 54. 15 57. 71	. 0105 . 400 . 5375	. 003 — . 381 (Broke.)	. 0075 . 019	2 45 2 35 0 18	. 2989 x . 2997	21. 95 54. 52 58. 11	21.80 pounds raised before reaching torsion of 0.01.
655	A co 38 *	20. 90 52. 60 54. 50	. 01 . 490 . 607	. 003 + . 482 (Broke.)	. 007 . 008	2 30 2 36 0 15	. 295 x . 2955	21. 85 54. 99 56. 97	

TABLE 26.—*TORSIONAL TESTS of steel gun-wires*—Continued.

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0″.3 x 0″.3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
656	A co 39 *	21.80	.01	.0025	.0075	2 00	.2991 x .300	21.88	
		57.05	(Lost.)	.485	(Broke.)	2 30			Ultimate torsion, doubtful.
657	A co 40 *	22.65	.01	.0025	.0075	1 45	.2992 x .2999	22.74	
		56.68	.400	.3835	.0165	2 35		56.93	
		58.95	.501	.481	.020	0 16		59.21	
		59.55	.5315	(Broke.)		0 06		59.81	
658	A co 41 *	21.60	.01	.0025	.0075	1 30	.2997 x .299	21.74	
		53.71	.400	.380 +	.020	2 41		53.95	
		57.00	.538	(Broke.)		0 15		57.37	
659	A co 12 *	21.21	.01	.0025	.0075	2 41	.2976 x .297	21.78	
		50.53	.501	.484 +	.017	3 21		51.89	
		52.00	.589	(Broke.)		0 20		53.40	
660	A co 13 *	19.00	.01	.0015	.0985	0 52			
		50.43	.500	.4835	.0165	3 49			
		51.50	.549	(Broke.)		0 16			
661	A co 14 *	19.83	.01	.003	.007	1 24	.297 x .2965	20.48	
		44.92	.501	*.484	.017	2 36		46.39	
		47.47	.6465	(Broke.)		0 30		49.92	
662	A co 15 *	20.00	.01	.0025	.0075	1 03	.2965 x .2974	20.53	
		45.74	.500	.4845	.0155	3 43		46.95	
		48.54	.668	(Broke.)		0 31		49.83	
663	A co 16 *	21.57	.011 +	.0035	.0075	2 49	.297 x .2975	22.17	
		50.29	.500	.4835	.0165	2 49		51.69	
		51.90	.592	(Broke.)		0 15		53.35	
664	C H co 6 *	14.44	.0155	.01	.0055	7 18	.2985 x .2988	14.63	14.44 pounds raised before torsion of 0.01 was reached.
		35.24	.500	.49 —	.010	2 30		35.75	
		38.95	.7675	(Broke.)		1 41		39.47	

665	C H c o7*	14.19	.015	.008	.009	4 41	.2982 x .2988	14.40	14.19 pounds raised before torsion of 0.01 was reached.
		34.46	.501	.489	.012	3 06	....	34.98	
		37.98	.7955	(Broke.)	....	0 49	....	38.55	
666	C H co 8*	13.81	.011	.006	.005	3 58	.2998 x .2978	13.97	13.81 pounds raised before torsion of 0.01 was reached.
		34.59	.500	.488	.012	3 15	....	34.99	
		38.84	.777	(Broke.)	....	0 47	....	39.29	
667	C H co 9*	12.75	.0115	.0065	.0040	4 00	.298 x .299	12.95	12 75 pounds raised before torsion of 0.01 was reached.
		33.83	.500	.488	.012	2 55	....	34.35	
		38.00	.764	(Broke.)	....	0 36	....	38.57	
668	C H co 10	16.25	.023	.018	.05	6 00	....	......	16.25 pounds raised before torsion of 0.01 was reached.
		40.20	.500	.487	.013	3 34	....	......	
		44.00	.7635	(Broke.)	....	0 44	....	......	
672	T co 3* —...........	15.84	.01	.003	.007	3 40	.2990 x .301	15.84	
		50.92	.4375	(Broke.)	....	4 58	....	50.92	
673	H W co 13*	14.09	.0115	.006+	.0055	5 49	.2994 x .2983	14.18	14.09 pounds raised before torsion of 0.01 was reached.
		41.72	.500	.4835	.0165	3 08	....	41.99	
		43.14	.5875	(Broke.)	....	0 42	....	43.42	
674	H W co 14*	13.91	.011	.006	.005	6 38	.300 x .300	13.91	13 91 pounds raised before torsion of 0.01 was reached.
		40.89	.500	.4845	.0155	3 10	....	40.89	
		42.85	.617	(Broke.)	....	0 31	....	42.85	
675	H W co 15*	13.78	.01	.004	.006	3 00	.2973 x .2973	14.15	
		41.32	.500	.483	.017	3 23	....	42.45	
		43.50	.640	(Broke.)	....	0 45	....	44.69	
676	H W co 16*	14.47	.0155	.009	.0065	5 07	.300 x .299	......	14.47 pounds raised before torsion of 0.01 was reached.
		42.42	.500	.4845	.0155	3 06	....	......	
		44.17	.630	(Broke.)	....	0 25	....	......	
677	H W co 17*	14.44	.016	.01	.008	4 18	.299 x .29996	14.51	14.44 pounds raised before torsion of 0.01 was reached.
		41.95	.500	.485	.015	3 04	....	42.18	
		43.98	.6165	(Broke.)	....	0 26	....	44.22	
678	H W co 18*	13.85	.01	.004	.006	5 24	.2977 x .2965	14.25	
		41.27	.500	.4865	.0135	3 24	....	42.48	
		42.98	.624	(Broke.)	....	0 27	....	44.24	
679	H W co 19*	13.97	.01	.005	.005	4 20	.298 x .300	14.11	
		41.30	.500	.484	.016	3 14	....	41.72	
		43.19	.6295	(Broke.)	....	0 26	....	43.63	
680	H W co 20*	14.02	.01	.004	.003	2 25	.297 x .297	14.44	
		41.27	.500	.475	.025	3 00	....	42.53	
		43.37	.6285	(Broke.)	....	0 25	....	44.69	

* About.

TABLE 26.—*TORSIONAL TESTS of steel gun-wires*—Continued.

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0".3 x 0".3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
681	H W co 9 —	14.96	.01	.003	.007	4 05	.2984 x .298	15.19	
		47.32	.400	.379	.021	4 20		51.22	
		49.54	.500	.478	.022	0 44		53.62	
		51.40	.5968	(Broke.)		1 22		55.64	
682	H W co 9 —	15.38	.01	.003	.007	4 03	.298 x .299	15.61	
		49.97	.500	.4765	.0235	4 37		50.72	
		52.45	.632	(Broke.)		0 23		53.24	
683	A	13.46	.011	.0065	.0045	3 20	.3005 x .300	13.42	13.46 pounds raised before torsion of 0.01 was reached.
		33.62	.500	.488	.012	2 53		33.53	
		39.77	1.1395	(Broke.)		1 00		39.67	
684	B	15.15	.01	.004	.006	3 41	.302 x .303	14.78	
		37.72	.500	.487	.013	2 44		36.80	
		42.72	.913	(Broke.)		0 52		40.68	
685	C	14.68	.01	.0045	.0055	2 36	.3015 x .302	13.42	
		35.89	.500	.488	.012	3 10		34.26	
		41.01	.933	(Broke.)		0 57		40.30	
686	E	14.45	.01	.004	.006	2 42	.301 x .301	14.30	
		36.92	.500	.488	.012	2 48		36.66	
		42.44	.966	(Broke.)		1 36		42.01	
687	F	14.15	.01	.005	.005	3 48	.3013 x .3028	13.85	
		36.73	.512	.505	.007	2 39		34.98	
		42.13	1.036	(Broke.)		1 07		41.29	
688	G	15.98	.01	.0035	.0065	5 36	.305 x .303	15.35	
		38.45	.500	.4875	.0125	3 15		36.94	
		44.62	.982	(Broke.)		6 58		42.87	
689	K	14.45	.0265	.0205	.0060	4 20	.3038 x .3042	13.88	
		36.39	.5600	.547	.0130	3 06		34.96	
		41.30	1.024	(Broke.)		0 59		39.68	

690	M	13.71	.012	.007	.005	2 30	.301 x .3032	13.32	13.71 pounds raised before torsion of 0.01 was reached.
		35.54	.500	.487	.013	2 41		34.54	
		41.46	1.0865	(Broke.)		1 15		40.30	
691	N:	14.19	.0155	.01	.0055	2 18	.302 x .3025	13.82	14.19 pounds raised before torsion of 0.01 was reached.
		37.00	.500	.4865	.0135	2 26		36.74	
		43.00	.980	(Broke.)		0 48		41.96	
692	P	13.33	.01	.0055	.0045	1 20	.298 x .2985	13.46	
		34.22	.580	.571	.009	3 20		34.56	
		39.54	1.190	(Broke.)		1 11		39.93	
693	Q	13.18	.01	.006	.004	1 36	.302 x .302	12.19	
		33.59	.500	.489	.011	3 45		32.92	
		39.66	1.123	(Broke.)		1 20		38.87	
694	R	13.64	.01	.005	.005	2 08	.2967 x .297	14.07	
		33.49	.500	.4875	.0125	2 39		34.53	
		39.13	1.0485	(Broke.)		1 21		40.37	
695	S	13.95	.01	.0035	.0065	2 49	.301 x .3033	13.65	
		35.00	.500	.488	.012	2 49		34.25	
		41.50	1.750	(Broke.)		1 07		40.62	
696	V	14.51	.01	.0035	.0065	2 31	.3015 x .302	14.25	
		35.90	.500	.490	.010	1 47		35.27	
		41.24	.988	(Broke.)		0 53		40.52	
697	W	15.58	.01	.0035	.0065	3 31	.302 x .304	15.13	
		30.00	.500	.486	.014	3 14		29.13	
		43.32	.873	(Broke.)		1 10		41.07	
698	Y	14.80	.01	.0045	.0055	3 05	.304 x .3035	14.25	
		38.95	.500	.487	.013	3 08		37.50	
		42.44	.722	(Broke.)		0 44		40.86	
699	Z	13.88	.01	.0035	.0065	3 23	.3023 x .3028	13.48	
		36.93	.500	.4865	.0135	2 59		35.88	
		42.86	1.005	(Broke.)		1 16		41.63	
700	A A	13.94	.0155	.01	.0055	2 52	.301 x .3015	13.76	
		33.76	.500	.488	.012	2 29		33.34	
		42.00	1.115	(Broke.)		1 31		41.48	
701	A B	15.15	.01	.004	.006	4 27	.3016 x .3035	18.37	
		36.97	.500	.487	.013	5 06		36.05	
		43.27	1.016	(Broke.)		1 38		42.20	
702	A C	15.22	.01	.006	.004	4 16	.3035 x .3035	14.70	Cracks across one corner; broke about 3-16 of an inch outside of the clamps.
		37.26	.500	.487	.013	3 21		35.99	
		43.00	1.063	(Broke.)		1 03		41.53	

TABLE 26.—*TORSIONAL TESTS of steel gun-wires*—Continued.

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0″.3 x 0″.3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
703	A D	14.70	.01	.004 —	.006	4 24	.302 x .3045	14.23	
		37.62	.501	.489	.012	4 00		36.42	
		43.62	1.050	(Broke.)		1 11		42.23	
704	A F	13.91	.012	.0075+	.0045	3 42	.302 x .3015	12.65	13.91 pounds raised before 0.01 torsion was reached.
		35.74	.501	.488	.013	2 46		35.14	
		41.48	1.0535	(Broke.)		0 55		40.76	
705	A H	14.66	.01	.004 —	.006	3 10	.3028 x .3045	14.13	
		36.55	.500	.4875	.0125	2 51		35.24	
		42.29	.995	(Broke.)		1 23		40.78	
706	A I	14.16	.01	.004	.006	2 46	.3013 x .3013	13.97	
		36.25	.500	.4875	.0125	3 32		35.75	
		42.07	.973	(Broke.)		1 12		41.53	
707	A K	14.48	.01	.004	.006	3 16	.301 x .2996	14.43	
		35.52	.500	.487	.013	3 14		35.41	
		40.69	.910	(Broke.)		0 57		40.56	
708	A L	15.30	.01	.005	.005	3 27	.3025 x .3036	14.89	
		38.14	.500	.488 —	.012	3 05		36.39	
		43.20	.871	(Broke.)		1 59		41.90	
709	A O	14.33	.01	.004 —	.006	1 52	.3015 x .3024	14.05	
		36.00	.500	.488 —	.012	2 47		35.30	
		41.00	.910	(Broke.)		1 53		41.21	
710	S P R 1 *	16.85	.01	.0035	.0065	4 00	.2985 x .298	17.14	Torsion not quite ceased.
		49.82	.500	.4835	.0265	2 45		50.70	
		52.00	.649	(Broke.)		0 16		52.92	
711	S P R 2 *	17.05	.01	.003 +	.007	4 30	.298 x .2984	17.36	
		49.40	.500	.483	.017	2 05		50.50	
		52.33	.670 —	(Broke.)		0 25		53.28	

712	S P R 3 *	17.50	.01	.003 +	.007	3 00	.298 x .298	17.85	
		51.53	.500	.4845	.0175	1 55	....	52.57	
		53.70	.6375	(Broke.)	....	0 10	....	54.78	
713	S P R 4 *	16.07	.01	.0035	.0065	3 25	.298 x .2981	16.42	
		50.57	.500	.4800	.0200	2 01	....	51.56	
		52.48	.6215	(Broke.)	....	0 10	....	53.51	
714	S P R 5 *	16.97	.01	.0035—	.0065	3 30	.299 x .3017	16.91	
		49.05	.500	.4815	.0185	2 00	....	48.87	
		52.00	.654 —	(Broke.)	....	0 20	....	51.81	
715	S P R 6 *	16.65	.01	.003 +	.007	2 30	.299 x .2995	16.76	
		49.44	.500	.4825+	.0175	1 55	....	49.79	
		51.88	.6235	(Broke.)	....	0 10	....	52.24	
716	S P R 7 *	14.90	.015	.0085	.0065	4 00	.2975 x .297	15.31	14.90 pounds raised before torsion of 0.01 was reached.
		42.65	.500	.4865	.0135	1 45	....	43.84	
		45.33	.6765	(Broke.)	....	0 15	....	46.59	
717	S P R 8 *	14.50	.01	.0035+	.0065	1 30	.2975 x .2976	14.86	
		42.67	.501	.4865—	.0143	1 35	....	43.73	
		45.10	.629	(Broke.)	....	0 12	....	46.22	
718	S P R 10 *	14.57	.01	.004 —	.006	2 55	.2976 x .2999	14.75	
		43.80	.500	.486 +	.014	2 08	....	44.36	
		45.41	.604	(Broke.)	....	0 14	....	45.99	
719	S P R 11 *	14.00	.012	.0065	.0055	1 45	.300 x .2978	14.15	
		43.00	.500	.484	.016	2 01	....	43.46	
		46.21	.6715	(Broke.)	....	0 19	....	46.70	
720	S P R 12 *	14.00	.011	.006	.005	2 50	.298 x .298	14.28	14.00 pounds raised before torsion of 0.01 was reached.
		41.72	.500	.487	.013	1 55	....	42.56	
		44.46	.6885	(Broke.)	....	0 18	....	45.35	
721	S P R 13 *	14.90	.012	.007 —	.005	5 25	.3009 x .2983	14.95	14.90 pounds raised before torsion of 0.01 was reached.
		42.49	.500	.487	.013	2 00	....	42.64	
		45.31	.679	(Broke.)	....	0 20	....	45.47	
722	B S co 5*	14.36	.01	.004 —	.006	2 30	.2986 x .2976	14.64	
		40.72	.5025	.487 +	.0155	1 45	....	51.51	
		44.86	.860	(Broke.)	....	0 34	....	45.73	
723	B S co 6*	12.33	.03	.025 —	.005	1 35	.297 x .2964	12.73	
		32.28	.503	.491	.012	1 35	....	33.34	
		37.00	.9335	(Broke.)	....	0 48	....	38.22	
724	S P R 14*	17.00	.01	.0035—	.0065	3 58	.298 x .2979	17.35	
		48.74	.502	.4835—	.0185	2 20	....	49.74	
		52.05	.6735	(Broke.)	....	0 30	....	50.31	

TABLE 26.—*TORSIONAL TESTS of steel gun-wires*—Continued.

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0″.3 x 0″.3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
725	S P R 15*	17.30 49.38 52.74	.01 .501 .680	.0035 .483 (Broke.)	.0065 .018	3 55 2 30 22	.2993 x .301	16.89 48.23 51.51	
726	S P R 16*	16.52 48.70 51.61	.01 .501 .644	.0035 .4835 (Broke.)	.0065 .0175	4 15 2 00 0 15	.2997 x .3011	16.52 48.70 51.61	
727	S P R 17*	16.75 49.05 52.45	.01 .500 .646	.0035 .483 (Broke.)	.0065 .017	2 55 2 14 0 23	.301 x .2998	16.75 49.05 52.45	
728	S P R 18*	16.96 48.70 52.00	.01 .500 .684	.0035 .483 (Broke.)	.0065 .017	2 30 1 50 0 18	.2985 x .2981	16.96 48.70 52.00	
729	S P R 19*	17.63 50.89 53.62	.01 .500 .648	.0035 .483 (Broke.)	.0065 .017	3 20 2 02 0 21	.300 x .3013	17.63 50.89 53.62	
730	S P R 21*	16.70 47.30 50.95	.01 .502 .6855	.0035 .485 (Broke.)	.0065 .017	3 40 2 15 0 20	.2982 x .2983	17.05 48.31 52.04	
731	S P R 22*	16.80 48.26 51.17	.01 .503 .675	.0035 .487 (Broke.)	.0065 .016	2 10 1 55 0 16	.2991 x .3005	16.83 48.35 51.27	
732	S P R 25*	18.82 53.72 55.67	.01 .500 .619	.003 .4835 (Broke.)	.007 .0165	5 50 2 15 0 20	.3008 x .2995	18.79 53.64 55.58	
733	S P R 27*	17.66 52.82 55.49	.01 .501 .627	.003 .4825 (Broke.)	.007 .0185	2 40 1 52 0 14	.2993 x .300	17.71 52.90 55.66	

734	S P R 1*	15. 45 48. 36 50. 85	.01 .505 .650†	.003 + .488 (Broke.)	.007 .017	2 50 2 05 0 20	.299 x .2982	15. 66 49. 04 51. 56	
735	S P R 2*	15. 75 48. 62 50. 70	.01 .501 .620	.0035 .4835 (Broke.)	.0065 .0175	1 40 2 10 0 12	....	....	
736	S P R 3*	16. 41 50. 73 52. 57	.01 .501 .620†	.0035 .4825 (Broke.)	.0065 .0185	3 50 1 50 0 18	.2997 x .299	16. 51 51. 05 52. 90	
737	S P R 4*	16. 80 50. 97 52. 97	.01 .502 .6235	.0035– .486 (Broke.)	.0065 .016	3 45 2 05 0 12	.2981 x .2985	17. 09 51. 86 53. 89	
738	S P R 5*	14. 93 47. 73 50. 24	.01 .502 .6375	.0035 .4875 (Broke.)	.0065 .0145	3 10 1 50 0 14	.2988 x .302	14. 76 47. 53 50. 03	
739	S P R 6*	15. 48 47. 58 49. 40	.01 .502 .634	.0035 .483 (Broke.)	.0065 .019	3 55 1 50 0 20	.2996 x .2986	15. 77 48. 49 50. 35	Badly cracked across one corner throughout its length.
740	S P R 7*	12. 90 41. 81 44. 53	.0105 .501 .662	.0045 + .484 + (Broke.)	.0060 .017	3 00 1 45 0 18	.2974 x .2975	13. 21 42. 89 45. 68	12. 90 pounds raised before torsion of 0.01 was reached.
741	S P R 8*	13. 20 41. 60 43. 95	.01 .502 .6375	.004 – .4915 (Broke.)	.006 .0105	3 35 1 43 0 15	.2977 x .2972	13. 54 42. 68 45. 09	Strain was not released as quickly as usual.
742	S P R 10*	12. 95 42. 22 44. 38	.01 .503 .623	.004 .488 (Broke.)	.006 .015	3 40 1 40 0 18	.2997 x .2979	13. 10 42. 63 44. 91	
743	S P R 11*	12. 20 41. 46 44. 97	.01 .501 .654	.0035 .484 (Broke.)	.0065 .017	3 55 1 45 0 18	.2975 x .3002	12. 34 41. 94 45. 50	A seam running through one side near center.
744	S P R 12*	13. 30 41. 81 43. 59	.01 .501 .606	.0035 .4845 (Broke.)	.0065 .0165	3 20 1 40 0 12	....	....	A defect near a corner.
745	S P R 13*	13. 45 42. 38 44. 91	.01 .505 .677	.004 .491 (Broke.)	.006 .011	2 48 1 40 0 10	.300 x .298	13. 58 42. 82 45. 37	
746	S P R 14*	15. 65 48. 68 50. 97	.01 .501 .6315	.003 + .4825 (Broke.)	.007 .0185	4 16 1 45 0 15	.2982 x .298	....	

† About.

TABLE 26.—*TORSIONAL TESTS of steel gun-wires*—Continued.

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0".3 x 0".3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
747	S P R 15*	16.20 49.45 51.69	.01 .501 .634 +	.0035 – .485 (Broke.)	.0065 .016	4 30 2 00 0 16	.3005 x .2996	....	
748	S P R 16*	16.00 48.48 50.55	.01 .501 .605	.0035 .483 (Broke.)	.0065 .018	4 40 1 41 0 16	.300 x .3015	....	Cracks across a corner.
749	S P R 17*	16.09 49.38 51.52	.01 .500 .622	.0035 .485 (Broke.)	.0065 .015	3 50 1 55 0 22	.301 x .2998	....	
750	S P R 18*	15.71 48.10 50.73	.01 .500 .632	.0035 .481 (Broke.)	.0065 .019	2 55 1 50 0 32	.2986 x .2985	....	
751	S P R 19*	16.60 49.82 51.81	.01 .501 .602	.003 + .481 (Broke.)	.007 .020	3 00 1 32 0 15	.300 x .3011	....	
752	S P R 21*	15.40 47.12 48.75	.0115 .502 .612	.005 — .487 (Broke.)	.0065 .015	3 00 2 25 0 16	.2983 x .2985	....	
753	S P R 22*	15.45 47.62 49.61	.01 .502 .6015	.0035 .4835 (Broke.)	.0065 .0185	5 09 1 50 0 11	.3006 x .2995	....	
754	S P R 25*	17.50 53.02 54.94	.01 .5015 .600	.003 .481 (Broke.)	.007 .0205	4 55 2 05 6 10	.2995 x .3013	....	
755	S P27 *	15.20 51.10 52.18	.01 .501 .569	.003 .483 — (Broke.)	.007 .018	3 40 1 50 0 08	.2996 x .3001	....	

756	B S co 5*	12. 50	.01	.004 —	.006	4 00	.2994 x .2982		
		41. 15	.502	.487	.015	2 00			
		43. 99	.694	(Broke.)		0 15			
757	B S co 6*	11. 10	.021	.016	.005	5 52	.2971 x .2964		11.10 pounds raised before torsion of 0.01 was reached.
		32. 00	.500	.4875	.0125	1 26			
		36. 05	.8475	(Broke.)		0 32			
758	H W co 13*	13. 95	.013	.0075	.0055	7 00	.2995 x .2984		13. 95 pounds raised before torsion of 0. 01 was reached.
		42. 45	.500	.484	.016	1 30			
		44. 00	.627	(Broke.)		0 12			
759	H W co 14*	13. 55	.012	.007 +	.005	5 15	.300 x .2989		13. 55 pounds raised before torsion of 0. 01 was reached.
		41. 76	.500	.484 +	.016	1 50			
		43. 83	.6355	(Broke.)		0 13			
760	H W co 15*	13. 65	.0105	.005	.0055	6 50	.2979 x .2972		13. 65 pounds raised before torsion of 0. 01 was reached.
		41. 94	.500	.485 +	.015	2 05			
		43. 50	.6075	(Broke.)		0 12			
761	H W co 16 *	13. 75	.01	.004	.006	4 30	.2988 x .3007		
		42. 60	.500	.4855	.0145	2 00			
		44. 40	.623 +	(Broke.)		0 18			
762	H W co 17*	14. 00	.013	.0075	.0055	7 45	.2987 x .3003		14. 00 pounds raised before torsion of 0. 01 was reached.
		42. 68	.500	.4860	.0140	1 53			
		44. 26	.622	(Broke.)		0 10			
763	H W co 18*	13. 65	.01	.004	.006	7 55	.2976 x .2972		
		41. 88	.500	.485	.015	1 50			
		43. 57	.611	(Broke.)		0 10			
764	H W co 19*	13. 85	.01	.004	.006	7 00	.3003 x .2985		
		41. 98	.500	.486 —	.014	1 48			
		44. 00	.6465	(Broke.)		0 10			
765	H W co 20*	13. 82	.01	.0035	.0065	11 00	.2974 x .2979	14. 20	
		45. 88	.501	.4845	.0165	1 50		47. 14	
		43. 76	.6285	(Broke.)		0 13		44. 96	
766	S P R 14*	16. 80	.01	.003 +	.007	7 00	.2982 x .2987	17. 06	
		48. 62	.500	.483 —	.017	1 50		49. 37	
		51. 15	.645	(Broke.)		0 25		51. 93	
767	S P R 15*	16. 60	.01	.0035	.0065	10 05	.2998 x .3008	16. 55	
		49. 02	.500	.483	.017	2 00		48. 87	
		51. 86	.648	(Broke.)		0 24		51. 70	
768	S P R 16	16. 90	.01	.0035	.0065	9 15	.3006 x .3003	16. 88	
		49. 03	.500	.4835	.0165	1 50		48. 99	
		51. 66	.625	(Broke.)		0 17		51. 61	

TABLE 26.—*TORSIONAL TESTS of steel gun-wires*—Continued.

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0″.3 x 0″.3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
769	S P R 17*	16.55	.01	.003 +	.007	4 30	.301 x .300	16.40	
		48.89	.500	.483	.017	1 55	....	48.46	
		51.90	.667	(Broke.)	....	0 18	....	51.43	
770	S P R 18*	16.80	.01	.0035	.0065	5 00	.2985 x .2988	17.02	
		48.10	.500	.483 —	.017	1 55	....	48.77	
		50.45	.623	(Broke.)	....	0 16	....	51.13	
771	S P R 19*	16.95	.01	.0035	.0065	5 30	.3011 x .2995	16.89	
		49.70	.500	.485	.015	1 50	....	49.55	
		50.87	.572	(Broke.)	....	0 15	....	50.71	
772	S P R 21*	16.00	.01	.0035	.0065	4 50	.2984 x .2982	16.27	
		46.95	.500	.486 —	.014	1 40	....	47.75	
		49.14	.630	(Broke.)	....	0 12	....	49.98	
773	S P R 23*	16.45	.01	.0035	.0065	6 00	.3003 x .2995	16.46	
		47.95	.500	.4835+	.0165	1 50	....	47.99	
		50.59	.638	(Broke.)	....	0 15	....	50.64	
774	S P R 25*	17.80	.01	.003 +	.007	6 32	.3012 x .2998	16.72	
		52.57	.500	.482	.018	2 00	....	52.30	
		54.80	.632	(Broke.)	....	0 15	....	54.53	
775	S P R 27*	17.40	.01	.003 +	.007	4 31	.2993 x .3004	17.42	
		51.67	.500	.4815	.0185	1 55	....	51.75	
		53.68	.6055	(Broke.)	....	0 16	....	53.77	
776	S P R 29*	17.35	.01	.0035	.0065	5 47	.2981 x .2985	17.64	
		50.03	.500	.483	.017	1 56	....	50.91	
		51.81	.5765	(Broke.)	....	0 08	....	52.70	
777	S P R 31*	15.00	.01	.004	.006	2 20	.2976 x .298	15.33	Torsion not entirely ceased.
		43.77	.500	.486	.014	1 40	....	44.75	
		45.74	.615	(Broke.)	....	0 13	....	46.76	

778	S P R 32*	14.17	.01	.004	.006	3 45	.2978 x .2981	14.46	
		43.44	.501	.4875	.0135	1 30		44.33	
		46.30	.688	(Broke.)		0 20		47.36	
779	S P R 34*	14.90	.01	.0035 +	.0065	6 00	.2977 x .2981	15.21	
		43.64	.500	.486	.014	1 31		44.57	
		45.33	.6235	(Broke.)		0 11		46.30	
780	12 IN B	10.75	.0115	.0075	.0040	4 40	.2999 x .300	10.75	10.75 pounds raised before torsion of 0.01 was reached.
		36.60	.500	.4885	.0115	1 40		36.61	
		39.82	.750 +	(Broke.)		0 25		39.83	
781	12 IN B	11.05	.01	.0065	.0035	10 20	.300 x .300	11.05	Torsion ceased at each point noted in the test of this specimen. (Specimens Nos. 780 and 781 were drawn from part of a 12-inch gun-tube made by Messrs. Thos. Firth & Son, Sheffield, England.)
		12.70	.025	.020	.005	25 30		12.70	
		35.15	.503	.495	.008	38 00		35.15	
		36.70	.6035	.590	.0135	39 00		36.70	
		37.95	.7115	(Broke.)		20 10		37.95	
782	S P R 1*	16.30	.01	.0035	.0065	5 15	.2978 x .2985	16.60	Cracks on one side.
		48.10	.500	.483	.017	2 05		48.99	
		50.00	.635	(Broke.)		0 20		50.93	
783	S P R 2 *	16.35	.01	.0035	.0065	4 35	.2977 x .3003	16.52	Cracks.
		48.43	.500	.4835 +	.0165	1 50		48.93	
		50.96	.6585	(Broke.)		0 19		51.48	
784	S P R 3*	17.10	.01	.0035 –	.0065	5 00	.300 x .2991	17.07	
		51.10	.500	.482 –	.018	2 12		51.32	
		52.95	.6185	(Broke.)		0 15		53.18	
785	S P R 4 *	17.20	.01	.003 +	.007	6 00	.298 x .298	17.54	
		50.64	.500	.483 –	.017	2 00		51.66	
		51.16	.6095	(Broke.)		0 15		52.19	
786	S P R 5*	16.40	.01	.0035	.0065	3 29	.2984 x .3017	16.39	Seams.
		48.63	.500	.4835	.0165	2 01		48.60	
		50.15	.605	(Broke.)		0 12		50.12	
787	S P R 6*	15.70	.01	.0035	.0065	4 24	.2991 x .2983	15.90	
		47.70	.560	.483 +	.017	2 00		48.32	
		49.23	.595	(Broke.)		0 13		49.97	
788	S P R 7*	13.60	.01	.004	.006	2 20	.2975 x .297	13.98	
		41.47	.500	.485 –	.015	1 58		42.63	
		43.69	.657	(Broke.)		0 13		44.89	
789	S P R 8*	14.00	.014	.008	.006	4 30	.2975 x .2971	14.43	A slight seam; 14.00 pounds raised before torsion of 0.01 was reached.
		41.18	.500	.484	.016	1 58		42.46	
		43.30	.639	(Broke.)		0 12		44.65	

TABLE 26.—*TORSIONAL TESTS of steel gun-wires*—Continued.

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0″.3 x 0″.3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
790	S P R 10	13. 80	.0105	.004	.0065	6 00	.2975 x .2995	13. 95	13.80 pounds raised before 0.01 torsion was reached; a seam.
		41. 99	.501	.4865	.0145	1 40		42. 46	
		43. 70	.6265	(Broke.)		0 13		43. 70	
-791	S P R 11*	14. 15	.01	.004	.006	8 50	.2977 x .2997	14. 33	Seams.
		42. 95	.500	.486	.014	1 50		43. 51	
		45. 56	672 —	(Broke.)		0 20		46. 15	
792	S P R 12*	13. 68	.0115	.005	.0065	5 50	.2971 x .298	14. 02	13.68 pounds raised before 0.01 torsion was reached.
		41. 66	.500	.4855—	.0145	1 35		42. 70	
		44. 15	.687	(Broke.)		0 18		45. 25	
793	S P R 13*	74. 05	.0115	.0065	.0050	5 30	.300 x .2979	74. 82	14.05 pounds raised before 0.01 torsion was reached; seamy.
		41. 80	.500	.487 —	.013	1 40		42. 23	
		44. 38	.680	(Broke.)		0 19		44. 79	
794	S P R 14*	16. 64	.01	.0035	.0065	7 12	.2981 x .2983	16. 94	
		48. 96	.500	.483 +	.017	2 03		49. 84	
		51. 02	.624 —	(Broke.)		0 18		51. 93	
795	S P R 15*	15. 52	.01	.0035—	.0065	8 28	.2994 x .301	15. 48	Cracks across one side.
		49. 00	.500	.4825	.0165	2 00		48. 89	
		51. 29	.642	(Broke.)		0 21		51. 18	
796	S P R 16*	16. 55	.01	.0035	.0065	7 50	.3013 x .3004	16. 30	
		48. 94	.500	.4835 +	.0165	2 00		48. 52	
		50. 64	.6045	(Broke.)		0 15		50. 21	
797	S P R 17*	15. 85	.01	.0035 +	.0065	6 55	.3007 x .2996	15. 82	A very slight seam.
		47. 73	.500	.4845	.0155	1 52		47. 65	
		50. 94	.6045	(Broke.)		0 20		50. 86	
798	S P R 18*	16. 13	.01	.0035	.0065	7 45	.2983 x .2986	16. 37	Slight defect along one edge.
		47. 98	.500	.484	.016	1 44		48. 71	
		50. 13	.620	(Broke.)		0 10		50. 89	

799	S P R 19*	16.80	.01	.0035	.0065	7 00	.301 x .2997	16.74	
		49.92	.500	.4835—	.0165	1 50	....	49.74	
		52.10	.638	(Broke.)	....	0 18	....	51.92	
800	S P R 21*	15.64	.01	.0035	.0065	3 10	.2981 x .298	15.94	A seam.
		46.85	.500	.485	.015	2 00	....	47.77	
		48.77	.6215	(Broke.)	....	0 14	....	49.73	
801	S P R 22*	15.95	.01	.0035+	.0065	6 40	.3005 x .2993	15.95	
		47.42	.500	.484 —	.016	1 40	....	47.42	
		49.95	.650—	(Broke.)	....	0 22	....	49.95	
802	S P R 25*	17.35	.01	.0035	.0065	11 15	....	17.30	A slight seam on two sides.
		52.00	.490	.484	.006	2 05	.2995 x .301	51.87	
		53.51	.581	(Broke.)	....	0 17	....	53.37	
803	S P R 27*	17.60	.01	.005 —	.005	7 10	.2993 x .3001	17.63	A very slight seam.
		52.40	.500	.482 +	.018	1 50	....	52.51	
		54.67	.600	(Broke.)	....	1 22	....	54.89	
804	S P R 29*	16.85	.01	.0035	.0065	4 50	.2983 x .2984	17.13	
		50.05	.500	.4825—	.0175	2 00	....	50.88	
		52.06	.6065	(Broke.)	....	0 13	....	52.92	
805	S P R 31*	14.65	.012	.0065+	.0055	5 45	.2978 x .298	14.93	A seam.
		43.57	.500	.4865	.0135	1 55	....	44.48	
		46.19	.6515	(Broke.)	....	0 12	....	47.15	
806	S P R 32*	14.60	.01	.004	.006	8 00	.2978 x .2979	14.90	A slight seam on two sides.
		43.38	.500	.4865	.0135	1 40	....	44.22	
		46.00	.6465	(Broke.)	....	0 18	....	47.00	
807	S P R 34*	11.00	.0105	.0035+	.0070	3 00	.2982 x .2985	11.18	11.00 pounds raised before torsion of 0.01 was reached.
		38.40	.500	.4855	.0145	1 55	....	38.94	An open seam on two opposite sides.
		42.98	.6785	(Broke.)	....	0 18	....	43.69	
808	B S co 5.............	14.30	.0155	.010	.0055	17 00	.2996 x .2986	14.43	14.30 pounds raised before torsion of 0.01 was reached.
		40.97	.500	.4865	.0135	1 45	....	41.35	
		44.18	.739	(Broke.)	....	0 18	....	44.59	
809	B S co 6	12.05	.0275+	.0215	.0060	7 40	.2965 x .2971	12.43	12.05 pounds raised before torsion of 0.01 was reached.
		32.40	.500	.490	.010	1 45	....	33.44	
		36.40	.890	(Broke.)	....	0 34	....	37.57	
810	H W co 13	14.15	.01	.004	.006	2 45	.2985 x .2992	14.30	
		42.00	.501	.4865—	.0145	1 38	....	42.47	
		44.00	.642 —	(Broke.)	....	0 28	....	44.49	
811	H W co 14	13.75	.01	.005	.005	2 47	.2999 x .2985	13.86	
		41.64	.501	.4855	.0155	1 45	....	41.98	
		43.09	.6265	(Broke.)	....	0 12	....	43.44	

TABLE 26.—*TORSIONAL TESTS of steel gun-wires*—Continued.

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0''.3 x 0''.3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
812	H W co 15	14.03	.01	.004 —	.006	5 28	.2972 x .298	14.36	
		41.81	.501	.487	.014	1 40		42.80	
		43.21	.604—	(Broke.)		0 09		44.24	
813	H W co 16	14.20	.016+	.015	.001	5 30	.299 x .3004	14.23	14.20 pounds raised before torsion of 0.01 was reached.
		42.45	.500	.487	.013	1 48		42.56	
		44.67	.643	(Broke.)		0 12		41.78	
814	H W co 17	14.00	.0245	.018—	.0165	12 00	.3001 x .2987	14.08	14 00 pounds raised before torsion of 0 01 was reached.
		42.38	.500	.486—	.014	1 38		42.63	
		44.91	.6785	(Broke.)		0 15		45.17	
815	H W co 18	13.55	.01	.004	.006	3 00	.297 x .2977	13.91	
		41.44	.501	.487	.014	2 12		42.55	
		43.79	.639	(Broke.)		0 15		44.97	
816	H W co 19	13.90	.020	.0145	.0055	6 48	.3002 x .2989	13.96	13.90 pounds raised before torsion of 0.01 was reached.
		41.52	.500	.4875	.0125	2 40		41.70	
		43.94	.662	(Broke.)		0 21		44.13	
817	H W co 20	14.08	.0195	.013 +	.0065	5 35	.297 x .2977	14.46	14.08 pounds raised before torsion of 0.01 was reached.
		41.78	.500	.4865	.0135	2 27		42.90	
		44.08	.6695	(Broke.)		0 13		45.27	
818	A co 12✱	21.30	.01	.0025	.0075	4 05	.2979 x .297	21.85	
		50.41	.500	.483 —	.017	1 30		51.77	
		52.49	.636	(Broke.)		0 16		53.86	
819	A co 13✱	20.75	.0105	.0035—	.0065	4 08	.2967 x .2974	21.37	20.75 pounds raised before torsion of 0.01 was reached.
		50.63	.501	.483	.018	1 45		52.15	
		52.29	.609	(Broke.)		0 12		53.86	
820	A co 14✱	20.17	.0105	.0035—	.0065	4 10	.2963 x .2974	20.81	20.17 pounds raised before torsion of 0.01 was reached.
		45.31	.500	.485 —	.015	1 40		46.48	
		48.03	.685 +	(Broke.)		0 14		49.55	

821	A co 15*	20. 10	.01	.003	.007	4 10	.298 x .2969	20. 62	
		45. 93	.500	.4875	.0125	1 50	....	47. 12	
		48. 83	.6945	(Broke.)	....	0 21	....	49. 33	
822	A co 16*	21. 40	.0105	.003	.0075	5 00	.2979 x .2978	22. 25	
		50. 68	.500	.4855	.0145	1 56	....	51. 75	
		52. 62	.6325	(Broke.)	....	0 11	....	53. 72	
823	A co 17*	20. 25	.0145	.0065 +	.0080	7 00	.2972 x .2972	20. 83	20.25 pounds raised before torsion of 0.01 was reached.
		44. 87	.500	.487	.013	1 32	....	44. 16	
		47. 83	.7085	(Broke.)	....	0 20	....	49. 21	
824	A co 18*	20. 70	.01	.003 –	.007	6 00	.298 x .2976	21. 15	
		48. 30	.500	.486	.014	1 32	....	49. 37	
		51. 00	.6675	(Broke.)	....	0 15	....	52. 13	
825	A co 19*	19. 80	.01	.003	.007	3 00	.2976 x .2977	20. 27	
		44. 77	.500	.487	.013	1 40	....	45. 83	
		47. 94	.735	(Broke.)	....	0 27	....	51. 13	
826	A co 20*	21. 70	.01	.0025	.0075	3 00	.2979 x .298	22. 15	
		51. 60	.500	.484	.016	2 00	....	52. 67	
		53. 05	.600	(Broke.)	....	0 13	....	54. 15	
827	A co 21*	20. 09	.0105	.003	.0075	2 30	.2981 x .298	20. 48	20.09 pounds raised before torsion of 0.01 was reached.
		45. 83	.500	.4865	.0135	1 58	....	46. 69	
		48. 75	.6895	(Broke.)	....	0 18	....	49. 71	
828	A co 22*	22. 50	.01	.0025–	.0075	4 00	.2995 x .2995	22. 61	
		61. 27	*.494	(Broke.)	....	1 25	....	61. 59	
829	A co 23*	19. 00	.025	.0175 +	.0075	30 15	.2985 x .2985	19. 52	19 pounds raised before torsion of 0.01 was reached. Torsion not entirely ceased.
		43. 71	.500	.4865	.0135	1 30	....	44. 87	
		46. 40	.697	(Broke.)	....	0 17	....	47. 63	
830	A co 24*	18. 60	.0105	.0035	.0070	5 40	.2989 x .2987	18. 82	18.60 pounds raised before torsion of 0.01 was reached.
		42. 80	.500	.4865	.0135	1 20	....	43. 37	
		45. 87	.719	(Broke.)	....	0 22	....	46. 36	
831	A co 25*	18. 75	.0161	.009	.0071	11 00	....	....	18.75 pounds raised before torsion of 0.01 was reached. Torsion not quite ceased.
		43. 95	.500	.487	.013	1 18	....	....	
		46. 50	.675	(Broke.)	....	0 13	....	....	
832	A co 26*	18. 25	.01	.0035	.0065	11 45	.2989 x .2984	18. 49	
		43. 20	.500	.4865	.0135	1 33	....	43. 78	
		45. 87	.670	(Broke.)	....	0 15	....	46. 48	
833	A co 27*	19. 20	.01	.0035 –	.0065	13 30	.2994 x .2993	19. 32	
		45. 05	.500	.486	.014	1 20	....	45. 34	
		47. 53	.6505	(Broke.)	....	0 15	....	47. 84	

* About.

TABLE 26.—*TORSIONAL TESTS of steel gun-wires*—Continued.

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0".3 x 0".3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
834	A co 28✱	18.70	.01	.0035--	.0065	6 30	.2993 x .2993	18.83	Torsion not quite ceased.
		44.84	.500	.4865 +	.0135	1 18	....	45.15	A slight seam on two sides.
		47.66	.6805	(Broke.)	....	0 18	....	47.99	
835	A co 29✱	19.07	.01	.0035—	.0065	4 00	.2985 x .2989	19.31	
		43.49	.500	.488 —	.012	1 10	....	44.07	
		46.20	.6885	(Broke.)	....	0 20	....	46.82	
836	A co 30✱	18.92	.01	.003 +	.007	8 30	.299 x .2985	19.14	
		45.56	.500	.4865	.0135	1 22	....	46.10	
		47.73	.641	(Broke.)	....	0 12	....	48.30	
837	A co 31✱	18.65	.0105	.0035	.0070	6 00	.2992 x .2987	18.84	18.65 pounds raised before torsion of 0.01 was reached.
		44.51	.500	.4865	.0135	1 30	....	44.98	
		47.05	.6755	(Broke.)	....	0 19	....	47.54	
838	A co 32✱	18.88	.01	.0035--	.0065	5 00	.2985 x .299	19.10	
		45.78	.500	.487	.013	1 20	....	46.43	
		48.49	.6675—	(Broke.)	....	0 14	....	49.07	
839	A co 33✱	20.62	.01	.003	.007	6 30	.299 x .2999	20.73	
		54.00	.500	.4835	.0165	1 30	....	54.29	
		54.77	.546	(Broke.)	....	0 05	....	55.07	
840	A co 34✱	21.80	.01	.0025	.0075	4 20	.2999 x .2994	21.87	
		58.09	.495	(Broke.)	....	2 05	....	58.27	
841	A co 35✱	21.91	.01	.002 +	.008	8 50	.3002 x .2998	21.91	
		60.70	.452 —	(Broke.)	....	1 58	....	60.70	
842	A co 36✱	21.95	.0105--	.003	.0075	3 45	.300 x .2994	21.99	21.95 pounds raised before torsion of 0.01 was reached. After releasing to note resilience, it broke without raising the same weight again.
		59.00	.500	.492	.018	2 00	....	59.13	
		59.00	.520	(Broke.)	....	0 05	....	59.13	

843	A co 37*	21.65 57.23 57.23	.01 .500 .5175	.003 .482 (Broke.)	.007 .018	6 30 1 50 0 03	.2994 x .3001	21.70 57.37 57.37	
844	A co 38*	20.10 52.99 54.02	.01 .500 .578	.013 + .484 (Broke.)	.007 .016	4 10 1 51 0 06	.2998 x .2991	20.21 53.28 54.49	
845	A co 39*	21.50 57.16	.01 .489	.003 — (Broke.)	.007	5 50 1 15	.3002 x .3002	21.45 57.03	
846	A co 40*	21.98 59.15 59.22	.01 .500 .5175	.0025 .482 - (Broke.)	.0075 .018	4 22 2 00 0 03	.3002 x .3005	21.90 58.94 59.01	
847	A co 41*	21.06 56.63 56.87	.01 .500 .524	.0025 .482 (Broke.)	.0075 .018	4 58 1 42 0 04	.3001 x .2991	21.12 56.81 57.05	
848	—O	13.60 33.05 39.67	.0245 .500 1.2695	.0230 .4895 (Broke.)	.... .0105	16 00 1 30 1 25	.301 x .3014	12.84 32.65 39.12	13.60 pounds raised before torsion of 0.01 was reached. Torsion not quite ceased. No. 848 was cut at the end of tensile specimen No. 170—.
849	O	13.62 33.83 39.91	.01 .500 1.169	.014 .491 (Broke.)	.006 .009	5 20 1 33 *1 10	.3006 x .3004	13.60 33.80 39.87	Torsion not quite ceased. No. 849 was cut at the end of tensile specimen No. 171—.
850	S P R 36*	14.16 33.12 37.11	.0295 — .500 .800	.0245 .4885 (Broke.)	.0050 .0115	8 45 1 32 0 35	.2955 x .2953	14.83 34.68 38.86	14.60 pounds raised before torsion of 0.01 was reached.
851	S P R 36*	13.62 32.94 37.05	.0275 .500 .866	.021 — .488 (Broke.)	.0065 .012	10 32 1 35 0 42	.2955 x .2955	14.24 34.46 38.76	13.62 pounds raised before torsion of 0.01 was reached.
852	A co 42*	18.15 46.40 48.78	.01 .500 .649	.003 + .4855 (Broke.)	.007 .0145	6 30 1 44 0 17	.2968 x .296	18.79 48.05 50.52	
853	A co 43*	17.38 42.89 45.89	.0125 .500 .716 —	.0065 .487 (Broke.)	.0060 .013	9 00 1 33 *0 20	.296 x .2968	17.99 44.41 47.52	17.38 pounds raised before torsion of 0.01 was reached. Torsion very nearly ceased.
854	A co 44*	16.55 42.05 45.05	.01 .500 .6945	.0035 .487 (Broke.)	.0065 .013	7 00 1 27 0 17	.2968 x .2959	17.15 43.59 46.74	
855	A co 45*	17.35 46.00 48.75	.01 .500 .6445	.003 .4835 (Broke.)	.007 .0165	9 00 1 33 0 16	.296 x .2969	18.63 49.40 52.35	A seam.

* About.

TABLE 26.—*TORSIONAL TESTS of steel gun-wires*—Continued.

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0″.3 x 0″.3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
856	A co 46*	14.02	.011	.003 +	.008	2 00	.2965 x .2969	14.48	
		44.87	.500	.482	.018	1 48		46.35	A seam.
		48.12	.6935	(Broke.)		0 20		49.70	
857	A co 47*	18.47	.01	.003	.007	5 00	.2961 x .2968	19.12	
		46.70	.500	.4855	.0145	1 40		48.36	
		49.08	.658	(Broke.)		0 16		50.82	
858	A co 48*	18.35	.01	.003 +	.007	4 45	.297 x .2962	18.96	
		46.76	.500	.486	.014	1 27		48.33	
		49.00	.661	(Broke.)		0 12		50.65	
859	A co 49*	18.65	.01	.003	.007	6 30	.296 x .2971	19.28	
		46.96	.500	.4845	.0155	1 42		48.55	
		49.00	.640	(Broke.)		0 12		50.66	
860	A co 50*	18.40	.01	.003	.007	6 45	.297 x .296	19.03	
		46.00	.500	.480	.020	1 40		47.59	
		48.91	.670	(Broke.)		0 16		50.60	
861	A co 51*	17.55	.011	.0035 +	.0075	5 00	.296 x .2972	18.14	17.55 pounds raised before reaching torsion of 0.01.
		43.20	.500	.486	.014	1 10		44.65	
		46.27	.709	(Broke.)		0 16		47.82	
862	A co 52*	16.25	.01	.0035	.0065	6 37	.296 x .297	16.81	
		40.80	.500	.486	.014	1 32		42.21	
		44.12	.746	(Broke.)		0 20		45.64	
863	A co 53*	18.05	.01	.003	.007	5 20	.2969 x .296	18.69	
		46.67	.499	.4825 +	.0165	1 28		48.33	
		49.45	.683	(Broke.)		0 17		51.21	
864	A co 54*	17.85	.01	.003 —	.007	60 20	.2961 x .297	18.45	
		46.00	.500	.486	.014	10 35		47.56	
		48.45	.6855	(Broke.)		0 17		50.10	

865	A co 55*	16.85 41.99 44.66	.01 .500 .6815	.0035 .487 (Broke.)	.0065 .013	5 00 1 10 0 15	.297 x .296	17.43 43.44 46.20	
866	A co 56 . *.......	17.45 43.27 46.43	.01 .500 .697	.0035— .484 (Broke.)	.0065 .016	4 30 1 12 0 12	.2969 x .296	18.06 44.81 48.08	
867	A co 57*	17.85 45.86 48.83	.01 .500 .697	.003 .4845 (Broke.)	.007 .0155	4 00 1 08 0 17	.2973 x .2963	18.77 47.24 50.40	
868	A co 58*............	18.85 46.45 48.85	.011 .500 .6445	.0035 .486 (Broke.)	.0075 .014	4 40 1 10 0 12	.2971 x. 2961	19.37 47.00 50.49	18.85 pounds raised before reaching torsion of 0.01.
869	A co 59*.......	17.85 44.78 47.64	.01 .500 .697—	.003 .4845 (Broke.)	.007 .0155	3 55 1 10 0 13	.2947 x .295	18.80 47.16 50.17	
870	A co 60*............	17.50 45.05 48.05	.01 .500 .7075	.0025 – .484 (Broke.)	.0075 .016	3 40 1 22 0 16	.2948 x .2951	18.41 47.30 50.55	
871	A co 61*............	14.05 41.97 45.00	.011 .500 .6465	.0035 .484-- (Broke.)	.0075 .016	2 05 1 20 0 16	....	....	14.05 pounds raised before reaching torsion of 0.01. A seam.
872	A co 62*............	16.30 44.75 47.54	.012 .500 .679	.003 .481 (Broke.)	.009 .019	4 00 1 30 0 14	....	....	Carried beyond torsion of 0.01 by mistake.
873	A co 42*............	17.30 46.32 48.44	.01 .500 .6315	.003 .4845 (Broke.)	.007 .0155	3 30 1 20 0 12	.2969 x .296	17.91 47.97 50.16	
874	A co 43............	16.30 42.72 45.69	.0105 .500 .695—	.0035 .487 (Broke.)	.0070 .013	4 00 1 40 0 15	.2961 x .2966	16.89 44.29 47.37	16.30 pounds raised before reaching torsion of 0.01.
875	A co 44*............	16.20 42.67 45.10	.01 .5005 .68 +	.0035 .4855 (Broke.)	.0065 .0145	4 40 1 20 0 16	.2967 x .2959	16.70 43.98 46.59	
876	A co 45*............	17.80 46.75 48.98	.01 .500 .6565	.003 .4855 (Broke.)	.007 .0145	5 45 1 28 0 10	.296 x .297	18.41 48.36 50.67	
877	A co 46*............	17.50 46.54 48.67	.01 .500 .640	.003 .484 (Broke.)	.007 .016	5 03 1 25 0 11	.2965 x .2969	18.78 49.96 52.24	

TABLE 26.—*TORSIONAL TESTS of steel gun-wire*.—Continued.

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0".3 x 0".3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
878	A co 47*............	17.35	.01	.0035 -	.0065	3 30	.2961 x .2969	17.95	
		46.52	.500	.486	.014	1 30	....	48.12	
		48.37	.6075	(Broke.)	....	0 13	....	50.04	
879	A co 48*............	17.90	.01	.0035	.0065	4 32	.2971 x .296	18.51	
		46.58	.500	.485	.015	1 27	....	48.16	
		48.97	.634	(Broke.)	....	0 11	....	50.63	
880	A co 49*............	12.20	.01	.003	.007	2 40	.296 x .297	12.62	
		46.60	.500	.486	.014	*1 30	....	48.21	
		49.10	.643	(Broke.)	....	0 12	....	50.79	
881	A co 50 *............	17.65	.01	.0035 -	.0065	3 40	.297 x .2965	18.22	
		45.98	.500	.4865	.0135	1 18	....	47.49	
		48.66	.6665	(Broke.)	....	0 10	....	50.25	
882	A co 51*............	16.35	.01	.0035 -	.0065	4 20	.296 x .2971	16.90	
		42.95	.500	.4845	.0155	1 16	....	44.39	
		45.56	.6765	(Broke.)	....	0 10	....	47.09	
883	A co 52*............	15.30	.01	.0035	.0065	4 06	.2966 x .2964	15.82	
		40.93	.500	.4875	.0125	1 30	....	42.34	
		44.05	.711	(Broke.)	....	0 17	....	45.57	
884	A co 53*............	17.63	.01	.003	.007	3 20	.2967 x .296	17.69	
		46.58	.500	.486	.014	1 17	....	48.29	
		48.80	.6475	(Broke.)	....	0 15	....	50.59	
885	A co 54*............	17.20	.01	.003	.007	3 15	.296 x .2971	17.78	
		45.97	.500	.485	.015	1 18	....	47.53	
		48.40	.669	(Broke.)	....	0 12	....	50.05	
886	A co 55*	16.57	.01	.0035	.0065	3 35	.2969 x .2961	17.14	
		42.45	.500	.4855	.0145	1 20	....	43.91	
		42.62	.640	(Broke.)	....	0 10	....	44.09	

887	A co 56*	16.75 43.65 46.46	.01 .500 .6901	.0035 .486 (Broke.)	.0065 .014	3 25 1 20 0 10	.296 x .2967	17.36 45.25 48.16	
888	A co 57 *	17.20 45.81 48.55	.01 .500 .6685	.0035 – .484 (Broke.)	.0065 .016	4 00 1 20 0 15	.2973 x .2961	17.76 47.32 50.15	
889	A co 58 *	17.60 46.35 48.48	.01 .500 .637	.003 .4855 (Broke.)	.007 .0145	4 30 1 20 0 10	.296 x .2974	18.18 47.88 50.07	
890	A co 59 *	17.35 44.88 47.99	.0115 .500 .690	.005 .483 (Broke.)	.0065 .017	5 00 1 08 0 12	.2945 x .295	18.29 47.32 50.60	17.35 pounds raised before reaching torsion of 0.01.
891	A co 60 *	17.20 44.93 47.72	.01 .500 .6765	.003 .4835 (Broke.)	.007 .0165	4 40 1 17 0 14	.2947 x .295	18.11 47.32 50.26	
892	A co 61 *	16.50 45.21 47.72	.0105 .500 .6535	.003 .4825 (Broke.)	.0075 .0175	3 00 1 27 0 14	.2954 x .2944	17.36 47.59 50.23	16.50 pounds raised before reaching torsion of 0.01.
893	A co 62 *	17.45 44.79 47.00	.01 .500 .641	.003 .4845 (Broke.)	.007 .0155	3 10 1 30 0 10	.2947 x .295	18.38 47.17 49.50	
894	A co 63 *	17.70 45.37 48.05	.01 .500 .678	.0035 – .484 + (Broke.)	.0065 .016	3 00 1 20 0 18	.2953 x .2948	18.60 47.68 50.50	
895	A co 64 *	17.16 44.95 47.80	.01 .500 .680	.003 + .481 (Broke.)	.007 .016	3 00 1 21 0 15	.2948 x .2952	18.04 47.27 50.27	
896	A co 65 *	17.90 44.99 47.45	.01 .500 .655	.003 .4835 (Broke.)	.007 .0165	4 08 1 28 0 16	.295 x .2947	18.85 47.38 49.97	
897	A co 66 *	17.40 44.98 48.00	.01 .500 .6935	.003 + .4835 (Broke.)	.007 .0165	3 30 1 18 0 12	.295 x .2948	18.31 47.35 50.52	
898	A co 67 x	17.35 44.97 47.88	.01 .500 .693	.003 .4845 (Broke.)	.007 .0155	3 10 1 12 0 13	.295 x .2948	18.25 47.21 50.38	
899	A co 68 *	17.61 44.74 46.96	.01 .500 .649	.003 .486 (Broke.)	.007 .014	5 00 1 25 0 10	.2949 x .295	18.52 47.07 49.43	

* About.

TABLE 26—*TORSIONAL TESTS of steel gun-wires*—Continued.

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0″.3 x 0″.3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns*	*Turns.*	*m. s*	*Inches.*	*Lbs.*	
900	A co 69 *	16.15	.01	.0035 –	.0065	5 00	.2948 x .295	17.00	
		40.93	.500	.4865	.0135	1 35		43.08	
		44.32	.717	(Broke.)		0 20		46.65	
901	A co 70 *	17.22	.01	.003	.007	3 40	.295 x .2951	18.09	
		44.82	.500	.4835	.0165	1 33		47.11	
		47.74	.694	(Broke.)		0 17		50.17	
902	A co 71 *	17.51	.01	.003 –	.007	3 00	.295 x .2952	18.39	
		44.10	.500	.4845	.0155	1 32		46.33	
		47.40	.7035	(Broke.)		0 18		49.80	
903	A co 72 *	16.38	.01	.003	.007	2 50	.295 x .2951	17.21	
		41.50	.500	.4865	.0135	1 18		43.60	
		44.80	.725	(Broke.)		0 18		47.07	
904	A co 73 *	17.35	.01	.003	.007	3 [illegible]0	.2952 x .295	18.22	
		45.25	.500	.483	.017	1 21		17.53	
		48.42	.6965	(Broke.)		0 17		50.87	
905	A co 74 *	16.30	.01	.003	.007	2 45	.2952 x .2951	17.11	
		42.18	.500	.484 +	.016	1 20		44.29	
		45.64	.731	(Broke.)		0 16		47.92	
906	A co 75 *	17.40	.01	.003	.007	3 10	.2954 x .295	18.10	
		44.03	.500	.485	.015	1 27		45.83	
		46.84	.665	(Broke.)		0 20		48.75	
907	A co 76 *	17.55	.01	.003	.007	3 20	.2962 x .2965	18.19	
		41.74	.500	.485	.015	1 21		46.38	
		47.69	.6855	(Broke.)		0 17		49.44	
908	A co 77 *	16.85	.0105	.003 +	.0070	3 40	.2964 x .2966	17.46	16.85 pounds raised before torsion of 0.01 was reached.
		42.51	.500	.4855	.0145	1 20		44.06	
		45.52	.7045	(Broke.)		0 18		46.18	

909	A co 78*	17.80 45.05 47.82	.01 .500 .667	.0035 .4865 (Broke.)	.0065 .0145	1 40 1 20 0 17	.2964 x .2967	18.49 46.98 49.45	A seam in center of one side.
910	A co 79*	16.66 42.43 45.52	.011 .500 .7065	.0035 + .4865 (Broke.)	.0075 .0135	3 40 1 19 0 16	.2962 x .2966	....	16.66 pounds raised before torsion of 0.01 was reached.
911	A co 80*	17.10 44.15 47.44	.01 .500 .0985	.003 – .4855 (Broke.)	.007 .0145	3 55 1 30 0 20	.2966 x .2968	....	
912	A co 81*	17.50 45.48 48.19	.01 .500 .678	.0035 .483 (Broke.)	.0065 .017	3 00 1 22 0 13	.2967 x .2968	....	
913	A co 82*	18.00 45.86 48.23	.01 .500 .654	.0025 + .4835 (Broke.)	.0075 .0165	3 01 1 26 0 18	.2967 x .2969	....	
914	A co 83*	16.55 42.20 45.47	.01 .500 .728	.003 .4855 (Broke.)	.007 .0145	3 05 1 25 0 20	.2963 x .2964	....	Strain was not released from this point as quickly as it should have been.
915	A co 84*	16.19 41.68 45.19	.01 .500 .747	.003 .486 (Broke.)	.007 .014	2 50 1 20 0 18	.2965 x .2966	....	
916	A co 63*	17.60 45.04 47.45	.01 .500 .656	.0025 + .484 (Broke.)	.0075 .016	2 43 1 20 0 11	.2956 x .2947	....	
917	A co 64*	16.60 41.65 47.00	.01 .500 .657	.0025 + .484 (Broke.)	.0075 .016	3 02 1 27 0 12	.2946 x .295	....	
918	A co 65*	17.15 44.50 46.88	.01 .500 .634	.003 .4835 (Broke.)	.007 .0165	3 00 1 22 0 10	.2945 x .2948	....	
919	A co 66*	16.85 44.74 47.30	.01 .501 .663	.0025 .486 – (Broke.)	.0075 .015	3 00 1 27 0 10	.295 x .2948	....	
920	A co 67*	16.75 44.69 47.45	.01 .500 .650 –	.003 .484 (Broke.)	.007 .016	3 03 1 18 0 12	.2947 x .295	....	
921	A co 68*	17.01 44.60 46.83	.01 .500 .650	.0025 .483 + (Broke.)	.0075 .017	2 30 1 18 0 10	.295 x .2952	....	

TABLE 26.—*TORSIONAL TESTS of steel gun-wires*—Continued.

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0''.3 x 0''.3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
922	A co 69*	15.82	.01	.003	.007	2 45	.2947 x .2946	....	
		41.00	.500	.484	.016	1 26	....	....	
		44.33	.7285	(Broke.)	....	0 11	....	......	
923	A co 70*	16.88	.01	.003	.007	3 10	.2949 x .2943	17.76	
		44.00	.500	.4845	.0155	1 25	....	46.46	
		47.00	.690	(Broke.)	....	0 13	....	49.63	
924	A co 71*	16.85	.01	.003	.007	3 45	.295 x .2953	17.69	
		43.97	.500	.483	.017	1 14	....	46.17	
		46.61	.669	(Broke.)	....	0 15	....	48.94	
925	A co 72*	15.75	.01	.003	.007	3 00	.2948 x .2949	16.58	
		41.25	.500	.4855	.0145	1 30	....	43.44	
		44.08	.697	(Broke.)	....	0 16	....	46.42	
926	A co 73*	17.05	.01	.0025	.0075	4 00	.295 x .2949	17.91	
		44.74	.500	.483	.017	1 31	....	47.06	
		47.66	.674	(Broke.)	....	0 11	....	50.13	
927	A co 74*	15.90	.01	.003	.007	3 00	.2948 x .2948	16.75	
		42.00	.500	.4835 +	.0165	1 24	....	44.21	
		45.44	.718	(Broke.)	....	0 17	....	47.86	
928	A co 75*	18.80	.01	.0025 +	.0075	4 00	.2951 x .2949	19.92	
		43.77	.500	.4835	.0165	1 30	....	46.39	
		46.27	.657	(Broke.)	....	0 12	....	49.04	
932	A co 79*	16.11	.01	.003	.007	3 00	.2964 x .2964	16.64	
		42.27	.500	.485	.015	1 20	....	43.66	
		45.41	.703	(Broke.)	....	0 12	....	46.90	
933	A co 80*	17.00	.010	.003	.007	3 45	.2965 x .2966	17.57	
		44.37	.500	.483	.017	1 23	....	45.88	
		47.63	.706	(Broke.)	....	0 12	....	49.25	

934	A co 81*	17. 35	.01	.003	.007	3 20	.2966 x .2966	18. 93	
		45. 86	.507	.4891 +	.0179	1 21	....	47. 44	
		48. 04	.6465	(Broke.)	....	0 12	....	49. 65	
935	A co 82*	17. 60	.01	.0025	.0075	3 35	.2969 x .2965	18. 18	
		45. 90	.500	.483	.017	1 21	....	47. 41	
		47. 98	.6315	(Broke.)	....	0 10	....	49. 56	
936	A co 83*	15. 90	.01	.0035	.0065	3 00	.2963 x .2969	16. 43	
		42. 19	.500	.4845	.0155	1 17	....	43. 61	
		45. 08	.710	(Broke.)	....	1 12	....	46. 59	
937	A co 84*	15. 80	.01	.0035	.0065	2 08	.2965 x .2966	16. 33	
		41. 60	.500	.4845	.0155	1 18	....	43. 01	
		44. 82	.7385	(Broke.)	....	0 12	....	46. 34	
938	S P R 37*	12. 50	.011	.006	.005	4 10	.2967 x .2967	12. 91	12.50 pounds raised before torsion reached 0.01.
		38. 74	.500	.487	.013	1 11	....	40. 11	
		41. 86	.7205	(Broke.)	....	0 20	....	43. 24	A small seam.
939	S P R 38*	12. 00	.01	.004	.006	3 40	.295 x .2972	12. 48	
		36. 97	.500	.4875	.0125	1 20	....	38. 41	
		39. 78	.714	(Broke.)	....	0 21	....	41. 37	
940	S P R 39*	12. 97	.01	.004	.006	4 35	.298 x .295	13. 41	
		38. 73	.500	.486	.014	1 20	....	40. 07	
		41. 61	.715	(Broke.)	....	0 21	....	43. 05	A small seam.
941	S P R 40*	11. 90	.012	.007	.005	4 15	.2993 x .2952	12. 23	11.90 pounds raised before reaching torsion of 0.01.
		36. 41	.500	.4865	.0135	1 11	....	37. 36	
		40. 00	.750	(Broke.)	....	1 30	....	41. 12	A seam.
942	S P R 41*	12. 95	.0011	.006	....	4 12	.2952 x .2996	13. 29	
		38. 05	.500	.4875	.0125	1 10	....	39. 05	
		40. 83	.698	(Broke.)	....	0 20	....	41. 90	
943	Ingot 838*	14. 50	.01	.0035	.0065	4 00	.3003 x .296	14. 77	
		45. 36	.500	.485	.015	1 22	....	46. 21	
		48. 60	.6875	(Broke.)	....	0 20	....	48. 90	
944	Ingot 844*	16. 20	.01	.0035	.0065	5 20	.3007 x .2962	16. 41	
		51. 07	.500	.482	.018	1 40	....	51. 85	
		53. 04	.62 +	(Broke.)	....	......	....	53. 85	
945	S P R 37*	12. 85	.01	.004	.006	4 30	.2966 x .2967	13. 28	
		38. 78	.500	.4855	.0145	1 10	....	40. 07	
		42. 70	.758	(Broke.)	....	0 30	....	41. 13	Two seams on one side.
946	S P R 38*	13. 50	.0195	.013 +	.0065	14 00	.2944 x .297	14. 09	13.50 pounds raised before torsion of 0.01 was reached.
		37. 38	.500	.4865	.0135	1 10	....	39. 01	
		40. 87	.773	(Broke.)	....	0 25	....	42. 66	

TABLE 26.—*TORSIONAL TESTS of steel gun-wires*—Continued.

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0″.3 x 0″.3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
947	S P R 39✱	14.50	.0105	.005	.0055	6 40	.2979 x .2949	13.99	13.50 pounds raised before torsion of 0.01 was reached.
		38.70	.500	.487	.013	1 17	....	40.18	
		41.94	.7305	(Broke.)	....	0 20	....	43.43	
948	S P R 40✱	11.20	.01	.004	.006	4 15	.2995 x .295	11.51	
		36.05	.500	.488	.012	1 10	....	37.05	Flaw discovered, after fracture, extending from outside to center.
		40.50	.7855	(Broke.)	....	0 22	....	41.63	
949	S P R 41✱	13.75	.016	.010	.006	12 00	.2996 x .2949	14.12	13.75 pounds raised before reaching torsion of 0.01.
		37.79	.500	.488	.012	1 18	....	38.74	
		41.00	.7335	(Broke.)	....	0 22	....	42.14	
950	Ingot 838✱	15.30	.01	.004 −	.006	6 00	.3002 x .2957	15.61	
		45.18	.500	.484	.016	1 19	....	46.12	
		48.36	.722	(Broke.)	....	0 20	....	49.37	
951	Ingot 844✱	16.40	.01	.003	.007	4 40	.296 x .3005	16.68	
		51.41	.500	.480	.020	1 40	....	52.31	
		53.39	.6235	(Broke.)	....	0 12	....	54.33	
952	S P R 52✱	15.86	.01	.0035	.0065	5 05	.3007 x .2957	16.14	This specimen and No. 957 were adjoining parts of the same wire.
		42.58	.500	.487	.013	1 30	....	42.35	
		45.40	.707	(Broke.)	....	0 17	....	46.22	
953	S P R 53✱	15.10	.01	.0035	.0065	5 30	.2952 x .296	15.77	Adjoined No. 958.
		42.95	.500	.486 +	.014	1 20	....	44.86	
		46.00	.700	(Broke.)	....	0 20	....	48.05	
954	S P R 54✱	15.55	.01	.0035	.0065	5 00	.2941 x .291	16.48	Adjoined No. 959.
		42.71	.500	.4835	.0155	1 20	....	45.28	
		45.47	.688	(Broke.)	....	0 18	....	48.21	
955	S P R 55✱	14.80	.01	.0035 +	.0065	6 45	.2972 x .2972	15.22	Adjoined No. 960.
		41.73	.500	.4865 +	.0135	1 10	....	42.93	
		45.60	.709	(Broke.)	....	0 21	....	46.91	

956	S P R 56 *	14.50	.01	.0035	.0065	4 40	.2953 x .2946	15.25	From opposite end of wire from which No. 961 was taken.
		40.75	.500	.484	.016	1 10		42.93	
		43.51	.6965	(Broke.)		0 12		46.91	
957	S P R 52 *	16.20	.01	.0035	.0065	5 40	.3005 x .296	16.48	See No. 952.
		43.63	.500	.4865	.0135	1 30		44.39	Nos. 957 to 961 inclusive were annealed at a slightly lower heat than the five preceding specimens. (Bronze in incipient fusion.)
		46.00	.671	(Broke.)		0 18		46.80	
958	S P R 53 *	15.11	.01	.0035+	.0065	3 00	.2951 x .2959	15.80	See No. 953.
		42.58	.500	.4865	.0135	1 40		44.55	
		45.77	.720	(Broke.)		0 20		47.88	
959	S P R 54 *	14.90	.01	.0035	.0065	4 00	.294 x .2942	15.81	See No. 954. Slightly defective on two corners.
		42.64	.500	.4845	.0155	1 35		45.24	
		45.45	.688	(Broke.)		0 18		48.32	
960	S P R 55 *	15.15	.01	.0035	.0065	5 30	.297 x .297	15.61	See No. 955.
		42.46	.500	.4865	.0135	1 17		43.77	
		45.95	.718	(Broke.)		0 21		47.35	
961	S P R 56 *	14.90	.0115	.006	.0055	4 30	.2952 x .2948	15.67	See No. 956.
		41.43	.500	.4855	.0145	1 12		43.57	
		44.39	.7025	(Broke.)		0 18		46.68	
962	S P R 42 *	14.60	.01	.0035+	.0065	4 00	297 x .2971	15.03	
		45.63	.5005	.486	.0145	1 31		47.00	
		48.62	.693	(Broke.)		0 16		50.08	
963	S P R 43 *	15.50	.011	.004	.007	5 00	.2951 x .2954	16.23	Three slight seams.
		41.85	.500	.485	.015	1 20		46.97	
		47.25	.647	(Broke.)		0 12		49.48	
964	S P R 44 *	11.25	.0375	.031	.0065	4 45	.2925 x .2925	12.10	Raised 11.25 pounds before reaching torsion of 0.01.
		28.99	.500	.419	.051	0 58		31.18	
		33.67	.9685	(Broke.)		0 35		36.21	
965	S P R 45 *	10.50	.0115	.007	.0045	4 44	.2926 x .293	11.29	
		28.64	.500	.49 —	.010	1 08		30.80	
		33.46	.9845+	(Broke.)		0 33		35.98	
966	S P R 46 *	17.28	.01	.003	.007	6 30	.2946 x .2944	18.26	
		52.37	.500	.4795	.0205	1 20		55.35	
		54.32	.633	(Broke.)		0 10		57.41	
967	S P R 47 *	16.30	.01	.003	.007	6 10	.2943 x .296	17.11	
		52.18	.500	.479	.021	1 45		54.89	A slight seam.
		54.82	.6195	(Broke.)		0 12		57.56	
968	S P R 48 *	13.60	.01	.003	.007	4 00	.2958 x .2947	14.26	
		38.50	.500	.487	.013	1 20		40.39	A slight seam.
		43.35	.719	(Broke.)		0 13		45.47	

* About.

TABLE 26.—*TORSIONAL TESTS of steel gun-wires*—Continued.

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.			Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0".3 x 0".3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.	Resilience.				
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
969	S P R 42 *...........	14.81	.01	.0035	.0065	4 40	.2966 x .298	15.21	A slight seam.
		45.19	.500	.4835	.0165	1 20	....	46.43	
		47.48	.6275	(Broke.)	....	0 10	....	48.78	
970	S P R 43 *...........	14.75	.01	.004	.006	4 00	.2953 x .2953	15.47	
		44.63	.500	.485	.015	1 20	....	46.75	
		47.96	.732	(Broke.)	....	0 14	....	50.28	
971	S P R 44 *.......	10.50	.01	.006	.004	4 30	.2929 x .2923	11.30	A very slight seam.
		29.10	.500	.490	.010	1 00	....	31.34	
		33.52	.9575	(Broke.)	....	0 39	....	35.90	
972	S P R 45 *............	10.40	.020	.0155	.0045	13 00	.2925 x .293	11.18	Raised 10.40 pounds before reaching torsion of 0.01; after standing a short time at 0.013 torsion increased rapidly.
		28.80	.500	.4895	.0105	0 53	....	30.98	
		33.35	.957	(Broke.)	....	0 45	....	35.87	
973	S P R 46 *........ ..	16.80	.01	.003	.007	6 30	.2945 x .294	17.79	
		51.78	.500	.4805	.0195	1 40	....	54.35	
		53.94	.6445	(Broke.)	....	0 10	....	56.63	
974	S P R 47 *...........	16.42	.01	.003	.007	6 00	.2959 x .2943	17.25	
		51.95	.500	.480	.020	1 30	....	54.57	
		53.60	.606	(Broke.)	....	0 10	....	55.74	
975	S P R 48 *.....	13.71	.01	.003	.007	4 40	.2956 x .2947	14.42	A seam at each end.
		38.41	.500	.487	.013	1 05	....	40.36	
		45.39	.8855	(Broke.)	....	0 33	.. ..	47.06	

976	S P R 52 ✱	16.20	.01	.0035	.0065	4 03	.299 x .3003	15.24	
		43.78	.500	.486 +	.014	1 10		43.92	
		46.62	.668	(Broke.)		0 23		46.76	
977	S P R 53 ✱	13.80	.01	.004	.006	6 35	.3005 x .2991	13.82	
		43.83	.500	.486	.014	1 10		43.91	
		46.52	.669	(Broke.)		0 17		46.60	
978	S P R 54 ✱	14.55	.01	.0035 +	.0065	4 45	.2995 x .3006	14.45	
		44.86	.500	.486	.014	1 20		44.83	
		47.75	.678	(Broke.)		0 13		47.72	
979	S P R 55 ✱	14.50	.0105	.0035	.0070	3 05	.2994 x .3005	14.50	
		43.45	.500	.4855	.0145	1 11		43.47	
		46.79	.719	(Broke.)		0 16		46.81	
980	S P R 56 ✱	13.87	.01	.0035	.0065	2 20	.300 x .299	13.93	
		42.81	.500	.4865	.0135	1 17		43.02	
		46.32	.7285	(Broke.)		0 19		46.55	A slight seam.
981	S P R 42 ✱	16.07	.01	.0035 +	.0065	3 40	.2993 x .3013	16.02	
		47.96	.500	.484	.016	1 24		47.81	A very slight seam.
		50.70	.6645	(Broke.)		0 18		50.54	
982	S P R 43 ✱	16.48	.01	.0035	.0065	3 57	.2993 x .3012	16.43	
		46.66	.500	.4845 +	.0155	1 30		46.54	
		50.48	.7295	(Broke.)		0 23		50.35	
983	S P R 44 ✱	12.00	.0285 +	.023	.0055	9 00	.2985 x .3003	12.07	Torsion nearly ceased at torsion of 0.01, but continued to the extent
		31.37	.500	.491	.009	1 05		31.55	given.
		36.55	.981	(Broke.)		0 40		36.76	
984	S P R 45 ✱	11.65	.01	.006	.004	6 30	.3002 x .2985	11.72	
		31.89	.500	.490	.010	1 18		32.09	
		86.27	.919	(Broke.)		0 40		86.83	
985	S P R 46 ✱	18.23	.01	.003	.007	4 55	.298 x .2997	18.44	
		54.96	.500	.482	.018	1 30		55.59	A slight seam.
		57.57	.645	(Broke.)		0 15		58.23	
986	S P R 47 ✱	17.90	.01	.003	.007	6 40	.2969 x .2986	18.30	
		53.87	.500	.482	.018	1 28		55.09	
		55.99	.632	(Broke.)		0 13		57.26	
987	S P R 48 ✱	15.25	.01	.0025 +	.0075	4 50	.301 x .3004	15.14	
		41.83	.500	.4885	.0115	1 12		41.53	
		47.70	.862	(Broke.)				47.36	A slight seam.
988	S P R 49 ✱	14.15	.01	.003	.007	6 00	.2963 x .2972	14.15	After fracture a seam was found extending from outside to center.
		37.49	.500	.488	.012	1 02		37.49	
		44.44	.893	(Broke.)		0 34		44.44	

TABLE 26.—*TORSIONAL TESTS of steel gun-wires*—Continued.

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0″.3 x 0″.3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
989	S P R 50 *	15.50	.01	.0035	.0065	3 15	.2993 x .3008	15.50	
		44.75	.500	.486	.014	1 15		44.75	
		47.67	.6975	(Broke.)		0 15		47.67	
990	S P R 51 *	15.55	.01	.0035	.0065	5 20	.2999 x .2999	15.55	
		43.90	.500	.4855	.0145	1 15		43.90	
		46.62	.679	(Broke.)		0 14		46.62	A very slight seam.
991	S P R * 42	16.02	.01	.0035	.0065	6 08	.2995 x .301	16.02	
		48.00	.500	.4835	.0165	1 30		48.00	
		51.13	.671	(Broke.)		0 13		51.13	
992	S P R * 43	15.85	.01	.0035	.0065	4 35	.2994 x .3011	15.85	
		47.00	.500	.4825	.0175	1 18		47.00	
		50.63	.7005	(Broke.)		0 18		50.03	
993	S P R * 44	12.05	.0365			7 20	.3002 x .2985	12.05	12.05 pounds raised before reaching torsion of 0.01.
		31.68	.500	.490	.010	1 03		31.68	
		36.19	.9075	(Broke.)		0 33		36.19	
994	S P R * 45	11.60	.032	.027 —	.005	14 00	.2984 x .3001	11.60	
		31.00	.500	.4895	.0105	1 05		31.00	
		35.75	.926	(Broke.)		0 35		35.75	
995	S P R * 46	18.30	.01	.003 —	.007	6 30	.2983 x .300	18.30	
		54.76	.050	.04805	.00195	1 30		54.76	
		57.70	.6675	(Broke.)		0 20		57.70	
996	S P R * 47	17.20	.01	.003 —	.007	4 00	.2975 x .2994	17.20	
		54.74	.500	.479	.021	1 50		54.74	
		57.05	.6375	(Broke.)		0 20		57.05	
997	S P R * 48	15.02	.01	.003 —	.007	3 20	.3004 x .3011	15.02	A seam.
		40.00	.500	.4855	.0145	1 09		40.00	
		47.77	.809	(Broke.)		0 33		47.77	

998	S P R 49*	14.05	.01	.0025 +	.0075	3 00	.2957 x .2969	14.57	
		37.68	.4995	.486	.0135	1 06	....	39.09	
		44.09	.821	(Broke.)	....	0 35	....	45.74	A slight seam.
999	S P R 50*	15.15	.01	.0035	.0065	4 40	.2996 x .3014	15.07	
		44.68	.500	.486	.014	1 20	....	44.46	
		48.01	.71 —	(Broke.)	....	0 30	....	47.77	
1000	S P R 51*	15.40	.015 +	.009 +	.006	3 30	.299 x .301	15.40	15.40 pounds raised before reaching torsion of 0.01.
		44.26	.500	.4855	.0145	1 19	....	44.26	
		47.46	.703 +	(Broke.)	....	0 18	....	47.46	
1001	S P R 52*	17.45	.037 +	.029	.008	3 20	.2987 x .3007	17.45	Torsion carried too far, by mistake.
		43.91	.500	.4845	.0155	1 05	....	43.91	
		47.18	.700	(Broke.)	....	0 18	....	47.18	
1002	S P R 53*	15.25	.01	.0035	.0065	4 30	.2989 x .300	15.33	
		45.00	.500	.486	.014	1 22	....	45.24	
		48.20	.697 +	(Broke.)	....	0 16	....	48.46	
1003	S P R 54*	15.80	.01	.0035	.0065	5 04	.3002 x .2993	15.80	
		45.14	.500	.4845	.0155	1 28	....	45.14	
		48.18	.687	(Broke.)	....	0 18	....	48.18	
1004	S P R 55*	14.60	.0115	.0065	.0050	4 00	.2991 x .3004	14.60	
		43.34	.500	.486	.014	1 20	....	43.34	
		47.31	.758	(Broke.)	....	0 22	....	47.31	
1005	S P R 56*	14.95	.01	.0035—	.0065	4 05	.3004 x .2992	14.95	
		43.40	.500	.486 +	.014	1 21	....	43.40	
		46.67	.725	(Broke.)	....	0 18	....	46.67	
1006	B S co	10.68	.0215	.017 +	.0045	8 45	.297 x .2977	10.98	Began to yield on raising 10.68 pounds.
		32.28	.500	.489	.011	1 30	....	33.15	
		36.25	.855	(Broke.)	....	0 43	....	37.22	A very slight seam.
1007	B S co S	10.68	.103	.094 +	.009	6 02	.2955 x .297	11.09	
		26.79	.500	.488	.012	1 20	....	27.82	
		33.56	.7625	(Broke.)	....	0 42	....	34.85	
1011	S P R 57*	12.80	.0115+	.0065	.0050	10 00	.296 x .2963	12.80	
		34.59	.500	.4885	.0115	1 27	....	31.59	
		38.62	.826	(Broke.)	....	0 30	....	38.62	
1012	S P R 58*	14.30	.01 +	.0035	.0065	6 03	.3013 x .3021	14.30	
		46.00	.500	.485 —	.015	1 50	....	46.00	
		49.27	.670	(Broke.)	....	0 26	....	49.27	Seams on three sides.
1013	S P R 57*	13.00	.01	.005	.005	7 13	.3002 x .3016	12.88	
		36.07	.500	.489	.011	1 20	....	35.74	
		40.38	.825	(Broke.)	....	0 45	....	40.01	

TABLE 26.—*TORSIONAL TESTS of steel gun-wires*—Continued.

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.		Measurement of cross-section.	Strain reduced to correspond to cross-section of 0''.3 x 0''.3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.						
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m.*	*s.*	*Inches.*	*Lbs.*	
1014	S P R 58*	15.55	.01	.0035	.0065	6	00	.301 x .302	15.31	
		46.62	.500	.4835	.0165	1	30	....	45.92	
		50.00	.688	(Broke.)	....	0	30	....	49.25	A seam on each of three sides.
1015	S P R 58*	15.50	.011	.004	.007	7	00	.3013 x .3022	15.24	Annealed together; each had slight seams on two sides.
		46.79	.500	.4845	.0155	2	05	....	46.01	
		50.00	.689	(Broke.)	....	0	22	....	49.17	
1016	S P R 58*	14.90	.01	.0035	.0065	3	40	.301 x .3023	14.64	
		46.27	.500	.4845	.0155	1	25	....	45.49	
		49.47	.6765	(Broke.)	....	0	15	....	48.62	
1017	S P R* 60	15.55	.0105	.0035—	.0070	3	55	.3013 x .300	15.44	.... From different rods.
		41.07	.500	.488 —	.012	1	22	....	41.39	A seam on each of two opposite sides
		47.61	.8115	(Broke.)	....	0	30	....	47.20	....
1018	S P R* 60	15.95	.01	.003	.007	5	00	.3005 x .3015	15.79	.... The same annealing.
		42.23	.500	.487	.013	1	20	....	41.80	A seam ....
		47.63	.7435	(Broke.)	....	0	26	....	47.15	....
1019	S P R* 61	15.34	.01	.0035+	.0065	4	40	.3007 x .3018	15.14	.... From different rods.
		45.82	.500	.485	.015	1	25	....	45.24	Seam separating cross-line, about 0''.01
		48.27	.656	(Broke.)	....	0	20	....	47.66	....
1020	S P R* 61	14.00	.0135	.008	.0055	4	40	.3005 x .3018	13.81	.... The same annealing.
		45.00	.500	.4855	.0145	1	20	....	44.49	Seam separating cross-line, 0''.8 ....
		47.94	.6595	(Broke.)	....	0	14	....	47.50	....
1021	S P R* 62	15.00	.01	.0035	.0065	4	40	.301 x .302	14.83	.... From different rods.
		45.68	.500	.4855	.0145	1	18	....	45.16	....
		48.40	.667	(Broke.)	....	0	13	....	47.85	....
1022	S P R* 62	15.20	.0115	.006	.0055	5	00	.3013 x .3018	14.96	.... The same annealing.
		45.66	.500	.487	.013	1	30	....	44.94	....
		48.07	.677	(Broke.)	....	0	14	....	47.32	....

1023	S P R* 63	15. 15	.01	.004	.006	5 40	.301 x .302	14. 97		From different rods.
		46. 12	.500	.486	.014	1 10		45. 59	A slight seam	
		48. 10	.620	(Broke.)		0 12		47. 55		
1024	S P R* 63	16. 35	.01	.004	.006	7 00	.301 x .302	16. 16	One side scored in drawing	The same annealing.
		47. 36	.500	.485	.015	1 18		46. 82		
		49. 14	.630	(Broke)		0 12		48. 58		
1025	S P R 61*	15. 00	.01	.004	.006	6 00	.3008 x .3016	14. 82		
		47. 00	.500	.486	.014	1 30		46. 44		
		49. 00	.618	(Broke.)		0 11		48. 41		
1026	S P R 61*	13. 20	.01	.0035+	.0065	3 00	.302 x .3004	13. 20		
		46. 55	.500	.484	.016	1 20		46. 55	Seam separating cross-line 0". 08.	
		48. 86	.6295	(Broke.)		0 12		48. 86		
1027	S P R 62*	14. 60	.01	.005	.005	6 00	.301 x .302	14. 60		
		46. 13	.500	.486	.014	1 20		46. 13		
		48. 43	.6345	(Broke.)		0 11		48. 43		
1028	S P R 62*	14. 60	.01	.004	.006	6 10	.3014 x .3018	14. 60		
		46. 00	.500	.4855	.0145	1 28		46. 00		
		48. 05	.6303	(Broke.)		0 10		48. 05		
1029	S P R 63*	47. 00	.500	.485	.015	1 40	.3008 x .3018	47. 00	Torsion of 0. 01 passed by mistake.	
		48. 72	.607	(Broke.)		0 09		48. 72		
1030	S P R 63*	15. 80	.01	.004	.006	5 50	.301 x .302	15. 80	Scored in drawing.	
		47. 79	.500	.4815	.0185	1 26		47. 79		
		49. 17	.589	(Broke.)		0 10		49. 17		
1031	—C 900	14. 60	.01	.004	.006	3 30	.3004 x .2987	14. 60		
		44. 96	.500	.484	.016	1 40		44. 96		
		48. 61	.738	(Broke.)		0 23		48. 61		
1032	—C 900	14. 60	.01	.004—	.006	4 60	.3006 x .298	14. 60		
		45. 00	.500	.485	.015	1 26		45. 00		
		48. 40	.7425	(Broke.)		0 20		48. 40		
1033	S P R 64*	13. 25	.018	.012	.006	7 12	.2995 x .2965	13. 51		
		40. 00	.501	.4875	.0135	1 47		40. 80		
		43. 18	.711	(Broke.)		0 22		44. 05		
1034	S P R 65*	12. 95	.0145	.0095	.0050	8 15	.2969 x .300	13. 15		
		41. 92	.600	.5875	.0125	1 50		42. 57		
		42. 48	.660	(Broke.)		0 10		43. 14		
1035	S P R 66*	14. 00	.0105	.005	.0055	8 10	.297 x .3007	14. 16		
		42. 53	.500	.486	.014	1 30		43. 02		
		45. 47	.701	(Broke.)				45. 99		

TABLE 26.—*TORSIONAL TESTS of steel gun-wires*—Continued.

Mark on specimen designating—			Torsion.						
No. of experiment.	Material.	Strain applied 1 foot from center.	Under strain.	Released.	Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0".3 x 0".3.	Remarks.
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
1036	S P R 67*	14.15	.01	.0065	.0035	9 00	.2975 x .301	14.24	
		43.10	.500	.486	.014	1 35	....	43.41	
		45.72	.6645	(Broke.)	....	0 18	....	46.05	
1037	S P R 68*	14.05	.01	.004	.006	7 20	.298 x .302	14.05	
		42.80	.500	.488	.012	1 30	....	42.80	
		44.78	.640	(Broke.)	....	0 17	....	44.78	
1038	S P R 69*	13.25	.014	.011	.003	6 00	.3025 x .292	13.62	
		41.90	.500	.486	.014	1 32	....	43.07	
		44.95	.700	(Broke.)	....	0 25	....	46.20	Two seams separating cross-lines 0".02 and 0".06.
1039	S P R 70*	15.00	.011	.0055+	.0055	6 00	.2989 x .3026	15.00	
		46.93	.500	.4855	.0145	1 05	....	46.93	
		48.75	.630	(Broke.)	....	0 12	....	48.75	Seam; cross-line separated about 0".01.
1040	S P R 71*	14.77	.01	.004	.006	8 00	.299 x .3026	14.77	
		45.63	.500	.4865	.0135	1 40	....	45.63	
		47.74	.6515	(Broke.)	....	0 20	....	47.74	
1041	S P R 64* C H	12.10	.01	.004	.006	5 20	.300 x .2967	12.10	
		40.00	.500	.486	.014	1 30	....	40.00	
		42.10	.629	(Broke.)	....	0 15	....	42.10	
1042	S P R 65* C H	12.12	.01	.005	.005	4 10	.2975 x .300	12.12	
		12.95	.0115	.010	.0015	4 15	....	12.95	(After resting one-half hour.)
		40.59	.500	.487	.013	1 35	....	40.59	
		42.05	.617	(Broke.)	....	0 10	....	42.05	
1043	S P R 66* C H	13.50	.01	.005	.005	5 00	.3007 x .2973	13.50	
		43.00	.500	.4855	.0145	1 30	....	43.00	
		45.00	.6345	(Broke.)	....	0 12	....	45.00	Seam separating cross-line about 0".02.
1044	S P R 67* C H	13.80	.0115	.007	.0015	6 20	.3012 x .2979	13.80	
		43.70	.500	.486	.014	1 27	....	43.70	
		45.03	.587	(Broke.)	....	0 12	....	45.03	Three seams; cross-lines separated from 0".02 to 0".05.

1045	S P R 68* C H	13. 25 43. 10 44. 42	. 01 . 500 . 578	. 005 . 486 (Broke.)	. 005 . 014	6 00 1 35 0 10	. 3018 x . 298	13. 25 43. 10 44. 42	
1046	S P R 69* C H	13. 45 43. 96 45. 00	. 01 . 500 . 590	. 004 . 484 (Broke.)	. 006 . 016	7 40 1 32 0 08	. 302 x . 298	13. 45 43. 96 45. 00	Seam separating cross-line 0''. 02.
1047	S P R 70* C H	15. 25 48. 43 48. 43	. 01 . 500 (Broke.)	. 004 . 485	. 006 . 015	6 00 1 45	. 2988 x . 3027	15. 25 48. 43 48. 43	
1048	S P R 71* C H	14. 78 47. 88 47. 88	. 01 . 500 . 5265	. 004 . 485 (Broke.)	. 006 . 015	8 35 1 40 0 00	. 3026 x . 2985	14. 78 47. 88 47. 88	
1049	S P R* 65	12. 60 39. 11 42. 11	. 0125 . 500 . 6975	. 008 . 487 + (Broke.)	. 0045 . 013	9 50 1 30 0 25	. 3003 x . 2969	12. 60 39. 11 42. 11	
1050	S P R* 66	13. 70 42. 00 44. 70	. 01 . 500 . 6795	. 004 . 4865 (Broke.)	. 006 . 0135	8 30 2 06 0 28	. 2971 x . 3004	13. 70 42. 00 44. 70	Seam; cross-line separated 0''. 04.
1051	S P R* 67	14. 20 43 00 44. 76	. 015 . 500 . 622	. 009 . 486 (Broke.)	. 006 . 014	11 40 1 40 0 22	. 2975 x . 3001	14. 20 43. 00 44. 76	
1052	S P R* 68	14. 05 42. 52 44. 97	. 0155 . 500 . 6635	. 010 . 4865 (Broke.)	. 0055 . 0135	14 30 1 30 0 20	. 2979 x . 3002	14. 05 42. 52 44. 97	Seam; cross-line separated about 0''.01.
1053	S P R* 69	13. 30 42. 00 44. 80	. 01 . 500 . 697	. 005 . 465 (Broke.)	. 005 . 035	5 30 1 30 0 21	. 302 x . 2979	13. 30 42. 00 44. 80	Seam; cross-line separated about 0''.02.
1054	S P R* 70	14. 96 47. 00 48. 90	. 01 . 500 . 610	. 004 . 485 (Broke.)	. 006 . 015	6 25 1 40 0 12	. 299 x . 3031	14. 96 47. 00 48. 90	
1055	S P R* 71	14. 52 45. 89 48. 35	. 01 . 500 . 6535	. 004 . 485 (Broke.)	. 006 . 015	7 30 1 37 0 20	. 3028 x . 2992	14. 52 45. 89 48. 35	
1056	Bes 3*	19. 65 49. 19	. 01 . 494	. 003 (Broke.)	. 007	4 30 1 50	. 2992 x . 2968	19. 65 49. 19	
1057	Bes 4*	19. 05 50. 19 50. 51	. 01 . 600 . 440	. 003 . 584 (Broke.)	. 007 . 016	3 20 1 45 0 05	. 2958 x . 294	19. 05 50. 19 50. 51	

TABLE 26.—*TORSIONAL TESTS of steel gun-wires*—Continued

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0″.3 x 0″.3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
1058	Bes 16*	21.00 51.97 52.42	.012 .500 .540	.006 .484 (Broke.)	.006 .016	4 00 2 08 0 10	.300 x .2961	21.00 51.97 52.42	
1078	A co 85*	22.00 60.55	.01 .470	.003 (Broke.)	.007	7 00 2 10	.302 x .3011	21.65 59.59	
1079	A co 86*	20.90 58.05	.01 .470	.0025 (Broke.)	.0075	6 00 1 58	.2984 x .2975	21.32 59.23	
1080	A co 87*	21.50 58.22	.01 .4595	.003 (Broke.)	.007	7 15 2 00	.2975 x .2989	21.89 59.87	
1081	A co 88*	19.90 55.76	.01 .4601	.003 (Broke.)	.007	6 20 1 48	.2975 x .2991	20.13 56.14	
1082	A co 89*	21.58 58.83	.01 .4775	.003 (Broke.)	.007	6 15 1 50	.2991 x .2975	21.96 59.87	
1083	A co 90*	21.65 59.00	.01 .472	.003 (Broke.)	.007	5 40 1 43	.3002 x .2975	21.90 59.68	
1084	A co 91*	20.85 58.38	.01 .472	.0025 (Broke.)	.0075	6 00 1 45	.2973 x .3008	21.05 58.96	
1085	A co 92*	16.35 53.70	.01 .4435	.0025 (Broke.)	.0075	5 00 1 33	.3007 x .2983	16.43 53.96	
1086	A co 93*	21.30 59.17	.01 .4765	.0025 (Broke.)	.0075	6 00 1 45	.2975 x .3008	21.49 59.72	
1087	A co 94*	21.20 59.43	.01 .500	.003 .482	.007 .018	5 30 1 48	.3008 x .2972	21.42 60.04	
1088	A co 95*	21.55 59.65	.01 .456	.003 (Broke.)	.007	6 00 1 54	.2975 x .3005	21.77 59.68	

1176	A co 85*	22.53	.01	.0025		10 00	.3014 x .3018		
		60.84	.476	(Broke.)		1 50			
1177	A co 86*	21.67	.01	.0025		6 00	.2972 x .2983		
		58.30	.500	.4815		1 45			Did not raise the weight after having been released.
1178	A co 87*	21.43	.01	.003		9 00	.2972 x .2980		
		57.67	.500	.4815		1 42			
		57.67	.5175	(Broke.)		0 03			
1179	A co 88*	20.59	.01	.003		7 00	.2972 x .299		
		54.20	.487	(Broke.)		1 33			
1180	A co 89*	21.80	.01	.0025		9 30	.2993 x .2972		
		58.71	.499	(Broke.)		1 40			
1181	A co 90*	21.90	.01	.0025		5 00	.3001 x .2975		
		58.58	.496	(Broke.)		1 30			
1182	A co 91*	21.90	.01	.0025		5 15	.3003 x .2972		
		57.78	.496	(Broke.)		1 20			
1183	A co 92*	21.92	.01	.003		7 00	.3001 x .2976		
		57.42	.467	(Broke.)		1 32			
1184	A co 93*	21.20	.01	.003		6 00	.2972 x .3005		
		58.24	.4715	(Broke.)		1 40			
1185	A co 95*	22.00	.01	.0025		6 00	.2972 x .3007		
		57.96	.4995	(Broke.)		1 30			
1186	A co 95*	21.82	.01	.0025		7 00	.2972 x .3005		
		57.90	.488	(Broke.)		1 38			
1187	A co 96*	18.70	.0115	.004		7 00	.3005 x .2976		
		49.98	.500	.4835		1 10			
		51.40	.595	(Broke.)		0 12			
1188	A co 97*	18.57	.01	.0035		8 00	.2977 x .2987		
		49.89	.500	.485		1 20			
		51.00	.583	(Broke.)		0 08			
1189	A co 98*	18.13	.01	.0035		8 40	.2975 x .2982		
		47.76	.500	.485		1 25			
		50.00	.6495	(Broke.)		0 18			Seam; cross-line separated 0".03.
1190	M co 4*	14.04	.021	.0155		*9 00	.2996 x .2973		Raised weight before torsion reached 0.01.
		39.55	.5025	.488		2 00			
		42.90	.7305	(Broke.)		0 38			

* About.

TABLE 26.—*TORSIONAL TESTS of steel gun-wires*—Continued.

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0''.3 x 0''.3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
1191	M co 5*	11.00	.033	.0285		2 40	.2989 x .297		Raised weight before torsion reached 0.01.
		30.79	.500	.489		1 30			
		35.56	.929	(Broke.)		0 42			
1192	M co 4*	12.25	.01	.005		5 40	.2994 x .2970		
		14.04	.021	.0155		2 00			
		39.42	.501	.4875		1 18			
		42.22	.689	(Broke.)		0 22			
1193	M co 5*	10.17	.01	.0065		4 30	.2995 x .2969		
		11.00	.018	.013		4 00			
		31.85	.500	.4895		1 25			
		36.26	.8875	(Broke.)		0 35			
1202	A co 85	20.00	.01	.0025		5 00	.3007 x .2985		Nos. 1202 to 1205 annealed in contact.
		52.67	.500	.4815		1 40			
		56.37	.7695	(Broke.)		0 30			
1203	A co 91	19.55	.01	.003		4 00	.3017 x .2989		
		51.86	.499	.4815		1 43			
		56.75	.789	(Broke.)		0 35			
1204	A co 138	43.00	.500	.4855		2 00	.2987 x .2986		
		48.78	.9685	(Broke.)		0 45			Seam; cross-line separated 0''.03.
1205	A co 144	18.95	.01	.003		6 00	.3015 x .2993		
		44.10	.499	.484		1 32			
		49.10	.912	(Broke.)		0 35			
1206	A co 85	19.70	.01	.003		3 00	.2984 x .301		Nos. 1206 to 1209 annealed in contact.
		50.19	.500	.483		1 35			
		54.94	.820	(Broke.)		0 30			
1207	A co 91	20.55	.01	.0035		4 45	.3021 x .299		
		51.93	.501	.483		1 35			
		56.08	.810	(Broke.)		0 35			

1208	A co 138	16.79	.0105	.0035	....	4 30	.2985 x .2981	....	
		41.98	.500	.486	....	1 20	....	....	
		47.13	1.025	(Broke.)	....	0 45	....	....	
1209	A co 144	18.10	.0245	.0175	....	8 00	.2991 x .3005	....	
		42.08	.499	.4855	....	1 35	....	....	
		47.22	1.0065	(Broke.)	....	0 50	....	....	
1210	A co 99*	18.75	.01	.003	....	6 00	.2976 x .2982	....	
		50.10	.500	.484	....	1 35	....	....	
		52.00	.6065	(Broke.)	....	0 12	....	....	
1211	A co 100*	18.70	.016	.009	....	10 15	.2979 x .2979	....	18.70 pounds raised before reaching torsion of 0.01.
		49.72	.500	.481	....	1 20	....	....	
		52.13	.638	(Broke.)	....	0 08	....	....	
1212	A co 101*	18.85	.0105	.0035	....	5 00	.2973 x .298	....	
		50.05	.500	.4825	....	1 30	....	....	
		52.03	.620	(Broke.)	....	0 16	....	....	
1213	A co 102*	18.75	.011	.0035	....	4 20	.2973 x .2981	....	
		50.00	.500	.4830	....	1 20	....	....	
		51.05	.570*	(Broke.)	....	0 12	....	....	
1214	A co 103*	18.50	.014	.0075	....	5 30	.298 x .2973	....	
		49.37	.501	.4835	....	1 20	....	....	
		51.00	.612	(Broke.)	....	0 10	....	....	Seam; cross-line separated about 0 . 03.
1215	A co 104*	18.90	.01	.003	....	6 00	.2974 x .298	....	
		50.00	.500	.483	....	1 20	....	....	
		51.70	.588	(Broke.)	....	0 10	....	....	
1216	A co 105*	18.85	.01	.003	....	5 30	.2973 x .298	....	
		50.00	.499	.482	....	1 20	....	....	
		51.84	.5875	(Broke.)	....	0 10	....	....	
1217	A co 106*	50.00	.500	.4825	....	1 40	.2975 x .2984	....	
		51.00	.5745	(Broke.)	....	0 10	....	....	
1218	A co 107*	19.20	.011	.004	....	5 30	.2976 x .2978	....	
		48.74	.500	.4835	....	1 30	....	....	
		50.64	.6065	(Broke.)	....	0 15	....	....	
1219	A co 108*	20.00	.01	.003	....	5 00	.2973 x .298	....	
		50.00	.500	.482	....	1 40	....	....	
		52.00	.5985	(Broke.)	....	0 12	....	....	
1220	A co 109*	19.80	.01	.003	....	4 00	.298 x .2977	....	
		51.10	.500	.482	....	1 20	....	....	
		53.04	.6275	(Broke.)	....	0 10	....	....	

* About.

TABLE 26.—*TORSIONAL TESTS of steel gun-wires*—Continued.

Mark on specimen designating— No. of experiment.	Mark on specimen designating— Material.	Strain applied 1 foot from center.	Torsion. Under strain.	Torsion. Released.	Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0''.3 x 0''.3.	Remarks.
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
1221	A co 110*	19.85	.01	.003	....	4 00	.2981 x .2973	....	
		50.17	.500	.483	....	1 15	....	....	
		52.58	.6235	(Broke.)	....	0 12	....	....	
1222	A co 111*	19.75	.011	.0035	....	4 00	.298 x .2974	....	
		49.61	.500	.4825	....	1 18	....	....	
		52.02	.610	(Broke.)	....	0 12	....	....	
1223	A co 112*	19.75	.011	.0035	....	4 20	.2973 x .2983	....	
		50.86	.499	.4805	....	1 12	....	....	
		52.10	.5875	(Broke.)	....	0 10	....	....	
1224	A co 113*	49.64	.500	.4835	....	1 30	.297 x .2983	....	
		52.00	.6235	(Broke.)	....	0 18	....	....	
1225	A co 114*	19.75	.0105	.0035	....	4 30	.2977 x .2983	....	
		49.60	.501	.484	....	1 30	....	....	
		51.62	.623	(Broke.)	....	0 12	....	....	
1226	A co 115*	20.00	.01	.003	....	4 00	.2975 x .3005	....	
		52.24	.500	.483	....	1 30	....	....	
		54.06	.629	(Broke.)	....	0 12	....	....	
1227	A co 116*	19.95	.01	.003	....	4 30	.3006 x .2975	....	
		50.37	.500	.483	....	1 40	....	....	
		52.85	.6395	(Broke.)	....	0 15	....	....	
1228	A co 128*	18.35	.0115	.005	....	5 30	.2975 x .3005	....	
		45.44	.500	.486	....	1 15	....	....	
		49.05	.733	(Broke.)	....	0 23	....	....	
1229	A co 129*	18.40	.01	.0035	....	5 00	.299 x .2977	....	
		44.60	.501	.4865	....	1 16	....	....	
		49.95	.7595	(Broke.)	....	0 30	....	....	

1230	A co 130*	18.40 44.76 48.38	.01 .500 .7285	.003 .486 (Broke.)	....	4 10 1 32 0 20	.2965 x .3009	....
1231	A co 131*	18.70 45.28 49.00	.01 .500 .7475	.0035 .4855 (Broke.)	....	5 30 1 20 0 23	.2967 x .301	....
1232	A co 132*	18.45 44.53 48.52	.01 .500 .738	.0035 .485 (Broke.)	....	4 00 1 28 0 20	.2958 x .2995	....
1233	A co 133*	18.50 45.78 48.63	.01 .500 .670	.0035 .4855 (Broke.)	....	4 00 1 18 0 15	.3007 x .2962	....
1234	A co 134*	18.00 44.98 48.64	.01 .500 .7395	.0035 .486 (Broke.)	....	3 15 1 28 0 22	.2985 x .2975	... .
1235	A co 135*	18.30 44.23 48.67	.01 .500 .785	.0035 .486 (Broke.)	....	3 00 1 25 0 30	.2976 x .2986	....
1236	A co 136*	18.50 44.66 49.00	.01 .500 .740	.0035 .486 (Broke.)	....	4 00 1 20 0 15	.2988 x .2974	....
1237	A co 137*	19.25 46.82 49.53	.01 .500 .640	.0035 .4835 (Broke.)	....	4 30 1 20 0 12	.2989 x .2979	....
1238	A co 138*	21.10 48.40 51.30	.01 .500 .686	.003 .484 (Broke.)	....	5 00 1 32 0 18	.2989 x .2979	....
1239	A co 139*	21.25 48.12 51.53	.01 .500 .704	.003 .484 (Broke.)	....	4 00 1 20 0 25	.2978 x .2989	....
1240	A co 140*	21.15 49.16 51.80	.01 .500 .703	.003 .485 (Broke.)	....	5 00 1 23 0 23	.2978 x .2994	... ...
1241	A co 141*	21.15 48.35 51.27	.01 .500 .676	.003 .4845 (Broke.)	....	5 00 1 30 0 18	.2994 x .298	....
1242	A co 142*	21.80 48.67 52.00	.01 .500 .703	.003 .4855 (Broke.)	....	4 45 1 20 0 30	.2981 x .2996	....

TABLE 26.—*TORSIONAL TESTS of steel gun-wires*—Continued.

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0''.3 x 0''.3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
1243	A co 143*	21.77	.01"	.003		4 00	.2984 x .2999		
		49.00	.499	.484		1 30			
		52.05	.6775	(Broke.)		0 20			
1244	A co 144*	21.60	.01	.003		4 00	.2985 x .2997		
		49.00	.500	.484		1 30			
		51.72	.6835	(Broke.)		0 12			
1245	A co 145*	21.40	.01	.003		4 00	.2986 x .300		
		48.84	.500	.4845		1 25			
		51.59	.6915	(Broke.)		0 20			
1246	A co 146*	21.51	.01	.003		4 00	.2997 x .2985		
		49.20	.500	.484		1 20			
		52.00	.680	(Broke.)		0 20			
1247	A co 147*	21.45	.01	.003		3 50	.2983 x .2997		
		49.34	.499	.483		1 18			
		52.38	.6875	(Broke.)		0 20			
1252	C K •	17.03	.010	.003		5 20	.2978 x .2972		
		47.53	.500	.4815		1 30			
		52.37	.838	(Broke.)		0 45			
1253	C K • •	17.50	.010	.003		7 00	.2976 x .2972		
		49.98	.500	.482		1 33			
		54.55	.800	(Broke.)		0 35			
1254	A co 85 •	20.75	.010	.003		5 25	.300 x .2976		
		52.00	.500	.483		2 05			
		56.32	.807	(Broke.)		0 45			
1255	A co 85 • •	20.75	.010	.003		2 50	.2972 x .2994		
		51.43	.500	.4825		2 60			
		55.83	.825	(Broke.)		0 30			

1256	A co 91 •	19.75	.010	.003		3 20	.2975 x .3008		
		49.23	.500	.4825		1 35			
		53.34	.790	(Broke.)		0 42			
1257	A co 91 ••	19.40	.010	.003		2 00	.2977 x .3003		
		49.00	.498	.4835		1 35			
		53.00	.851	(Broke.)		0 45			
1258	M co 4 * •	12.35	.01	.006	.004	2 30	.299 x .297		
		39.00	.500	.487	.013	1 30			
		41.82	.694	(Broke.)		0 30			
1259	M co 4 * ••	12.40	.010	.006	.004	2 10	.297 x .2968		
		38.93	.500	.4865	.0135	1 27			
		42.15	.718	(Broke.)		0 25			
1260	M co 5 * •	10.28	.010	.0065	.0035	1 50	.2965 x .2989		
		31.73	.500	.485	.015	1 27			
		35.94	.845	(Broke.)		0 37			
1261	M co 5 * ••	11.15	.0235	.019	.0045	6 15	.2965 x .2985		11.15 pounds raised before reaching torsion of 0.01.
		31.86	.500	.4885	.0115	1 15			
		36.10	.8445	(Broke.)		0 40			

TABLE 27.—*TORSIONAL TESTS of unannealed wires drawn from steel of various manufacturers.*

[For explanation of marks, see pages 136 to 140, inclusive.]

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0″.3 x 0″.3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
1274	H W co 4 UNA'D	27.00	.010	.001	.009	4 45	.3002 x .2992	27.00	
		56.98	.500	.480	.020	2 25		56.99	
		60.82	.957	(Broke.)		1 00		60.83	A very slight seam.
1275	C H co 4 S UNA'D	23.60	.010	.001	.009	3 00	.296 x .2936	24.86	
		53.00	.500	.480	.020	2 00		55.83	
		53.22	.530	(Broke.)		0 03		58.06	Seams separating cross-lines 0″.08 and 0″.03 on opposite sides.
1276	T co 3 * UNA'D	27.90	.010	.0015	.0085	2 25	.302 x .303	27.21	
		56.97	.300	.281	.019	1 32		55.56	
		58.37	.392	(Broke.)		0 12		56.93	Seam; cross-line separated about 0″.05.
1277	T co 6 * UNA'D	23.45	.010	.0015	.0085	1 30	.302 x .3019	22.99	Small flaw seen in fracture extending about 0″.275 from one end into the twisted part.
		68.99	.300	.275	.025	3 55		67.65	
		69.38	.325	(Broke.)		0 07		68.04	
1278	B S co * H D UNA'D	26.65	.010	.0015	.0085	2 00	.3017 x .299	26.55	This specimen was drawn in three draughts, without annealing.
		46.46	.500	.4845	.0155	1 40		46.29	
		48.00	.778	(Broke.)		0 30		47.83	
1279	B S co * UNA'D	23.45	.010	.002	.008	2 40	.299 x .3024	23.28	
		41.23	.500	.486	.014	1 40		40.94	
		43.15	.797	(Broke.)		0 30		42.84	
1280	N co I UNA'D	21.00	.010	.0015	.0085	2 42	.2925 x .2916	22.72	
		34.40	.500	.4865	.0135	2 15		37.23	
		38.21	.822	(Broke.)		0 30		41.35	
1281	C H co 5 I UNA'D	21.00	.001	.002		2 45	.2926 x .2926	22.61	
		38.49	.500	.4865	.0135	2 18		41.45	
		39.43	.729	(Broke.)		0 20		42.46	Seam; cross-line separated about 0″.05.
1282	C K-UNA'D	23.70	.010	.001	.009	3 00	.2981 x .2983	24.13	
		52.83	.500	.481	.019	1 50		53.79	
		56.09	1.1835	(Broke.)		0 50		57.11	

TABLE 28.—*TORSIONAL TESTS of hardened steel gun-wires.*

[For explanation of marks, see pages 136 to 140, inclusive.]

Mark on specimen designating— No. of experiment.	Mark on specimen designating— Material.	Strain applied 1 foot from center.	Torsion. Under strain.	Torsion. Released.	Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0″.3 x 0″.3	Remarks.
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
1283	H W co 4 HARDENED	16.00	.010	.003	.007	2 00	.2993 x .2981	16.20	Specimen failed at strain of 51 pounds, and torsion of 0.4, but did not break apart until torsion of about 0.8 was reached.
		41.22	.150	.134	.016	1 40		41.75	
		46.71	.250	.2335	.0165	0 30		47.32	
		51.00	.400*	(Broke.)				51.66	
1284	C K-HARDENED	17.70	.010	.003	.007	2 00	.2979 x .2974	18.12	
		28.26	.050	.039	.011	0 45		28.93	
		34.61	.100	.0865	.0135	0 35		35.43	
		38.81	.150	.1350	.0150	0 28		39.73	
		41.73	.200	.1835	.0165	0 25		42.72	
		44.00	.250	.233	.017	0 18		45.04	
		45.93	.300	.283	.017	0 20		47.82	
		47.50	.350	.332	.018	0 20		48.63	
		49.00	.400	.381	.019	0 20		50.16	
		50.30	.450	.431	.019	0 15		51.49	
		51.38	.500	.481	.019	0 18		52.60	
		52.31	.550	.531	.019	0 13		53.55	
		53.15	.600	.581	.019	0 15		54.41	
		54.00	.650	.631	.019	0 15		55.28	
		54.66	.700	.680	.020	0 12		55.96	
		55.28	.750	.730	.020	0 10		56.59	
		56.00	.800	.780	.020	0 18		57.31	
		56.67	.850	.830	.020	0 15		58.01	
		57.05	.900	.880	.020	0 12		58.40	
		57.55	.950	.930	.020	0 12		58.91	
		57.90	.972	(Broke.)		0 05		59.27	
1285	T co 2* HARDENED	20.45	.010	.001	.009	1 30	.2973 x .2995	20.77	Can be filed at one side of one end.
		35.90	.020	.004	.016	2 00		36.47	
		40.72	.030	.0115	.0185	2 05		41.37	
		44.28	.0415	.031	.0205	2 30		44.99	
		46.50	.0500	.029	.021	2 00		47.24	

*About.

TABLE 28.—*TORSIONAL TESTS of hardened steel gun-wires*—Continued.

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0".3 x 0".3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
		48.70	.060	.0375	.0225	2 45	....	49.48	
		50.60	.070	.047	.023	4 45	....	51.41	Small crack noticed, but no sound heard, with strain of about 50 pounds. Fracture chiefly in two transverse planes about 0".2 apart, joined by inclined surfaces. The interior metal can be filed, excepting at the corner where the crack above mentioned took place. A portion included in the clamps was found "glassy" inside.
		52.20	.080	.056	.024	2 50	....	53.04	
		53.50	.090	.065	.025	2 45	....	54.36	
		54.55	.100	.074	.026	3 00	....	55.42	
		56.43	.129	(Broke.)	....	0 30	....	57.33	
1286	B S co 5* HARDENED.	21.56	.01	.0015	.0085	2 30	.299 x .3012	21.53	
		31.60	.02	.008	.012	2 45	....	31.56	
		35.35	.03	.0165	.0135	1 30	....	35.31	
		38.35	.04	.025	.015	1 05	....	38.31	
		40.60	.05	.0335	.0165	2 30	....	40.55	
		42.60	.06	.0425	.0175	1 18	....	42.55	
		44.50	.07	.053	.017	4 50	....	44.45	
		46.00	.0825	.0645	.0180	2 18	....	45.95	
		47.15	.090	.0712	.0188	2 30	....	47.10	
		48.25	.100	.0810	.019	2 30	....	48.20	
		49.35	.110	.0910	.019	3 30	....	49.30	
		50.25	.120	.1005	.0195	2 45	....	50.19	
		51.20	.132	.112	.02	2 00	....	51.14	A crack heard and seen before raising 52 pounds.
		52.00	.1435	.1235	.02	3 20	....	51.94	
		52.00	.310	(Broke.)	....	*0 30	....	51.94	
1287	A co 91 HARDENED....	21.40	.010	.0025	.0075	2 30	.3009 x .2978	21.53	
		34.95	.020	.007	.013	4 30	....	35.27	
		40.23	.030	.0155	.0145	3 00	....	40.59	
		43.20	.042	.0245	.0175	2 40	....	43.48	
		45.20	.050	.0330	.0170	2 40	....	45.49	
		47.50	.060	.0415	.0185	5 00	....	47.80	
		50.00	.070	.051	.019	6 30	....	50.32	
		52.60	.090	.069	.021	4 00	....	52.94	

*About.

		54.10	.100	.080	.020	3 00	....	51.45	On re-applying 54.10 pounds the specimen partially failed, but was able to take a strain of 52.10 pounds before breaking.
		52.10	.31	(Broke.)	....	....	....	52.43	
1288	A co 138 HARDENED...	18.10	.010	.0035	.0065	2 00	.298 x .2965	18.60	
		21.60	.020	.0125	.0075	3 30	....	22.20	
		22.76	.030	.022	.008	2 00	....	23.39	
		24.27	.040	.031	.009	3 20	....	24.94	
		25.45	.050	.040	.010	2 00	....	26.16	
		29.45	.057	....	....	....	....	30.27	
		29.45	.080	.0569	.0231	3 00	....	30.27	
		30.50	.090	.079	.011	2 30	....	31.35	
		31.50	.102	.090	.012	2 00	....	32.38	
		32.70	.1165	.1035	.0130	8 00	....	33.61	
		33.35	.1225	.1100	.0125	5 30	....	34.28	
		34.90	.144	.1315	.0125	11 00	....	35.87	
		37.00	.170	.1575	.0125	18 00	....	38.03	
		37.55	.190	.177	.013	9 30	....	38.60	
		38.55	.2105	.196	.0145	10 00	....	39.62	
		40.00	.230	.217	.013	13 30	....	41.12	
		42.00	.280	.266	.014	18 00	....	43.17	
		50.77	.691	(Broke.)	....	1 15	....	52.19	

TABLE 29.—*TORSIONAL TESTS of tempered gun-wires.*

[For explanation of marks see pages 136 to 140, inclusive.]

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0″.3 x 0″.3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
1289	H W co 4 TEMPERED ..	19. 85	.01	.0005	.0093	2 30	.300 x .2979	20. 05	
		38. 60	.02	.0015	.0185	3 00	....	39. 00	At strain of 35 pounds faint quick cracks were heard, but none were visible.
		56. 25	.03	.0035	.0265	3 00	....	56. 84	
		67. 15	.04	.009	.031	2 30	....	67. 85	
		73. 05	.05	.016	.034	2 00	....	73. 81	Under strain of 73.05 pounds a seam separating cross-lines about 0″.02 was seen. Fracture shows a seam extending beyond the center.
		74. 81	.055	(Broke.)	....	0 35	....	75. 59	
1290	B S co 5 * TEMPERED ..	27. 65	.01	.001	.009	3 30	.2998 x .298	27. 95	Drawn from the rod without annealing.
		59. 80	.02	.002	.018	3 30	....	60. 45	
		78. 00	.03	.007	.023	3 30	....	78. 85	
		86. 10	.04	.015	.025	3 20	....	87. 04	
		89. 95	.05	.023	.027	3 30	....	90. 93	
		92. 20	.06	.031	.029	2 15	....	93. 21	
		94. 05	.07	.0405	.0295	1 40	....	95. 08	
		95. 10	.08	.050	.030	1 15	....	96. 14	
		95. 75	.09	.0605	.0295	2 28	....	96. 80	
		96. 50	.10	.069	.031	2 00	....	97. 56	
		97. 20	.11	.079	.031	2 00	....	98. 26	
		97. 50	.12	.089	.031	1 18	....	98. 57	
		98. 40	.13	.0985	.0315	2 40	....	99. 48	
		98. 40	.14	.108	.032	1 00	....	99. 48	
		98. 55	.15	.118	.032	2 40	....	99. 63	
		99. 05	.16	.1285	.0315	2 45	....	100. 13	
		99. 25	.17	.138	.032	2 45	....	100. 34	
		99. 65	.18	.148	.032	2 15	....	100. 74	
		99. 80	.19	.158	.032	1 30	....	100. 89	
		100. 10	.20	.168	.032	4 20	....	101. 20	
		100. 85	.21	.177	.033	4 00	....	101. 95	
		101. 00	.22	.188	.032	2 35	....	102. 11	
		101. 25	.23	.1975	.0325	2 20	....	102. 36	
		101. 30	.24	.2075	.0325	2 45	....	102. 41	
		102. 00	.25	.2173	.0325	4 00	....	103. 12	

		102. 10	.26	.227	.033	2 25	....	103. 22	
		102. 40	.27	.237	.033	3 00	....	103. 52	
		103. 08	.28	.247	.033	5 20	....	104. 21	
		103. 10	.29	.257	.033	2 00	....	104. 23	
		103. 20	.30	.2665	.0335	1 40	....	104. 33	
		103. 35	.31	.2765	.0335	2 00	....	104. 48	
		104. 25	.32	.287	.033	6 00	....	105. 39	After standing released one hour the torsion was found to be 0.2865.
		106. 30	.33	.2975	.0325	4 10	....	107. 46	
		106. 30	.337	(Broke.)	....	0 10	....	107. 46	After sustaining 106.30 pounds, applied the second time a few moments, the strain declined and specimen broke at torsion of 0.337.
1291	C K x TEMPERED	21. 80	.01	.0015	.0085	2 45	.2963 x .2971	22. 51	
		46. 30	.02	.0025	.0175	3 40	....	47. 82	
		67. 85	.03	.006	.024	5 20	....	70. 08	
		80. 50	.04	.011	.029	3 30	....	83. 15	
		86. 00	.05	.0185	.0315	3 15	....	88. 83	
		89. 71	.058	(Broke.)	....	1 30	....	92. 67	
1292	T co ✽ 16 TEMPERED ..	21. 90	.01	.0015	.0085	2 00	.295 x .2945	23. 09	Just before breaking several slight cracks were heard.
		40. 50	.0195	(Broke.)	....	1 15	....	42. 80	
1293	A co 91 TEMPERED....	23. 70	.010	.0015	.0085	2 00	.300 x .297	24. 05	
		49. 00	.020	.003	.017	4 00	....	49. 73	
		70. 85	.030	.0065	.0235	2 30	....	71. 91	
		79. 85	.038	(Broke.)	....	0 45	....	81. 05	
1294	A co 138 TEMPERED ...	21. 75	.010	.002	.098	1 30	.2972 x .2981	22. 26	
		43. 25	.020	.0035	.0165	2 00	....	44. 27	
		61. 09	.030	.007	.023	3 45	....	62. 54	
		69. 55	.040	.0135	.0265	1 30	....	71. 20	
		74. 00	.050	.021	.029	2 30	....	75. 76	
		76. 40	.060	.029	.031	2 45	....	78. 21	
		78. 40	.070	.039	.031	3 25	....	80. 26	
		79. 75	.080	.0485	.0315	1 40	....	81. 64	
		80. 75	.090	.0585	.0315	1 30	....	82. 67	
		81. 50	.100	.0685	.0315	1 30	....	83. 47	
		82. 00	.110	.0775	.0325	1 25	....	83. 95	
		82. 50	.120	.0875	.0325	1 30	....	84. 46	
		82. 65	.130	.0975	.0325	2 00	....	84. 61	
		82. 90	.140	.107	.033	3 50	....	84. 87	
		83. 30	.150	.1175	.0335	5 00	....	85. 28	
		83. 50	.160	.1270	.0330	7 00	....	85. 48	
		83. 90	.170	.1370	.0330	6 00	....	85. 89	
		84. 30	.180	.1470	.033	4 15	....	86. 30	
		84. 50	.190	.1565	.0335	4 30	....	86. 51	
		84. 70	.200	.1665	.0335	2 30	....	86. 71	
		84 75	.210	.176	.034	5 20	....	86. 76	
		85. 13	.220	.186	.034	8 00	....	87. 25	
		85. 45	.230	.1965	.0335	6 00	....	87. 48	
		85. 65	.240	.206	.034	4 00	....	87. 69	

TABLE 29.—*TORSIONAL TESTS of tempered gun-wires*—Continued.

Mark on specimen designating— No. of experiment.	Mark on specimen designating— Material.	Strain applied 1 foot from center.	Torsion. Under strain.	Torsion. Released.	Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0″.3 x 0″.3.	Remarks.
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
1294	A co 138 TEMPERED—Continued.	85. 90	. 250	. 216	. 034	7 00	....	87. 94	
		86. 35	. 260	. 226	. 034	5 15	....	88. 40	
		86. 50	. 270	. 2365	. 0335	3 35	....	88. 55	
		86. 55	. 280	. 2465	. 0345	3 05	....	88. 60	
		86. 70	. 290	. 2565	. 0335	5 00	....	88. 76	
		87. 10	. 300	. 266	. 034	7 20	....	89. 17	
		87. 35	. 310	. 276	. 034	4 45	....	89. 42	
		87. 45	. 320	. 286	. 034	5 00	....	89. 47	
		87. 55	. 330	. 2965	. 0335	7 00	....	89. 63	
		88. 07	. 340	. 306	. 034	10 00	....	90. 16	
		88. 60	. 350	. 316	. 034	8 00	....	90. 70	
		88. 63	. 363	. 328	. 035	5 00	....	90. 73	
		88. 70	. 380	. 346	. 034	7 00	....	90. 81	
		88. 85	. 390	. 3555	. 0345	7 00	....	90. 96	
		89. 12	. 400	. 3655	. 0345	8 30	....	91. 24	
		90. 67	. 4385	(Broke.)	....	3 00	....	92. 82	90.67 pounds were raised with torsion of 0.405, but torsion continued until it reached 0.4385, when specimen broke.
1295	H co I⁎ TEMPERED....	17. 60	. 010	. 0025	. 0075	2 10	. 2948 x . 2951	18. 51	
		38. 50	. 020	. 0035	. 0965	4 30	....	40. 50	
		50. 00	. 027	(Broke.)	....	2 30	....	52. 61	Has a flaw about 0″. 08 deep.
1296	H W co 4	27. 35	. 010	. 001	. 009	4 10	. 2998 x . 2989	27. 52	
		45. 80	. 020	. 005	. 015	3 30	....	46. 09	
		49. 52	. 030	. 0135	. 0165	2 10	....	49. 84	
		51. 65	. 0555	. 0375	. 0180	4 00	....	51. 98	
		56. 72	. 250	. 2295	. 0205	2 00	....	57. 08	
		60. 00	. 500	. 4885	. 0115	0 33	....	60. 39	
		61. 82	. 690	(Broke.)	....	0 18	....	62. 22	
1297	B S co 5⁎.............	28. 45	. 010	. 0005	. 0095	4 45	. 2991 x . 3015	28. 36	
		44. 85	. 020	. 0065	. 0135	6 00	....	44. 71	
		49. 05	. 030	. 0145	. 0155	4 50	....	48. 90	
		61. 00	. 250	. 229	. 021	1 00	....	60. 81	
		64. 61	. 433	(Broke.)	....	0 35	....	64. 41	

1298	C K	23.00	.010	.0015	.0085	3 50	.2974 x .2975	23.59	
		39.05	.020	.0065	.0135	6 40		40.06	
		43.85	.030	.014	.016	3 20		44.99	
		46.59	.050	.033	.017	2 35		47.90	
		51.68	.250	.2305	.0195	0 30		53.04	
		54.00	.500	.4795	.0205	0 23		55.40	
		55.13	.710	(Broke.)		0 20		56.56	
1299	T co 2*	23.13	.010	.001	.009	4 00	.2979 x 2085	23.55	
		45.60	.030	.0125	.0175	5 40		46.42	
		48.86	.040	.021	.019	2 00		49.74	
		60.00	.151	.1245	.0265	1 30		61.09	
		61.44	.232	(Broke.)		0 15		62.55	
1300	A co 91	23.85	.010	.0015	.0085	3 25	.2978 x .3008	24.09	
		40.00	.020	.0065	.0135	3 00		40.41	
		44.80	.031	.0155	.0155	3 00		45.26	
		54.12	.250	.2305	.0193	0 45		54.68	
		55.95	.500	.479	.021	0 20		56.53	
		56.50	.6165	(Broke.)		0 12		57.08	
1301	A co 138	25.60	.010	.0015	.0085	2 00	.298 x .2972	26.20	
		40.00	.020	.0065	.0135	2 00		40.94	
		45.00	.040	.0245	.0155	2 25		46.05	
		51.59	.250	.2325	.0175	0 40		52.80	
		53.42	.500	.483	.017	0 32		54.67	
		54.23	.750	.7305	.0195	0 28		55.50	
		54.48	.7715	(Broke.)		0 35		55.76	
1302	H co I*	23.08	.010	.001	.009	1 00	.295 x .2948	24.31	
		41.20	.020	.0035	.0165	3 30		43.40	
		47.70	.030	.012	.018	2 30		50.24	
		57.00	.150	.128	.022	0 50		60.04	
		58.46	.250	.228	.022	0 17		61.58	
		61.06	.500	.4755	.0245	0 50		64.26	
		61.15	.514	(Broke.)		0 05		64.35	
1303	H W co 4 TEMPERED	21.90	.010	.0005	.0095	2 00	.2994 x .2981	22.16	Split running from end to end; found, after breaking, to extend to center of specimen.
		42.65	.020	.0025	.0175	2 00		43.17	
		54.20	.030	.0075	.0225	1 43		54.86	
		59.55	.040	.0155	.0245	1 00		60.28	
		62.20	.050	.024	.026	0 40		62.96	
		64.20	.060	.034	.026	1 00		64.98	
		65.30	.070	.042	.028	1 00		66.10	
		66.15	.080	.0515	.0285	1 15		66.96	
		67.15	.097	.0675	.0295	1 10		67.97	
		68.77	.120	.090	.030	5 00		69.61	
		69.65	.140	.1095	.0305	8 00		70.50	
		70.20	.160	.129	.031	7 15		71.06	

TABLE 29.—*TORSIONAL TESTS of tempered gun-wires*—Continued.

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0″.3 x 0″.3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
1303	H W co 4 TEMPERED—Continued.	70.40	.170	.1305	.0305	2 30	....	71.26	
		72.10	.200	.1685	.0315	5 00	....	72.98	Cross-line over split separated about 0″.05.
		72.10	.210	.1785	.0315	1 15	....	72.98	
		72.15	.220	.1885	.0315	4 00	....	73.03	
		72.68	.238	(Broke.)	....	3 00	....	73.57	
1304	B S co. 5* TEMPERED..	18.40	.010	.0015	.0085	3 20	.3004 x .299	18.44	
		35.00	.020	.0035	.0165	2 30	....	35.09	
		45.00	.035	.0125	.0225	3 00	....	45.11	
		49.15	.050	.0265	.0235	3 00	....	49.27	
		50.70	.060	.0355	.0245	3 40	....	50.83	
		51.70	.070	.045	.025	6 00	....	51.83	
		52.65	.080	.0535	.0265	4 40	....	52.78	
		53.35	.090	.064	.026	2 15	....	53.48	
		53.85	.102	.0755	.0265	4 00	....	53.99	
		54.18	.110	.0835	.0265	3 00	....	54.32	
		54.75	.120	.0935	.0265	3 50	....	54.89	
		55.07	.130	.104	.026	4 50	....	55.21	
		55.55	.140	.1135	.0265	3 00	....	55.69	
		55.80	.150	.124	.026	2 00	....	55.94	
		56.22	.160	.134	.026	4 25	....	56.36	
		56.55	.170	.1435	.0265	4 00	....	56.69	
		57.10	.180	.154	.026	5 15	....	57.24	
		57.20	.190	.164	.026	2 00	....	57.34	
		57.60	.200	.174	.026	4 40	....	57.74	
		58.15	.210	.184	.026	5 30	....	58.30	
		58.45	.220	.194	.026	2 15	....	58.60	
		58.45	.230	.204	.026	1 30	....	58.60	
		58.90	.240	.214	.026	2 50	....	59.05	
		58.90	.2925	(Broke.)	....	0 15	....	59.03	
1305	C K TEMPERED	20.65	.010	.001	.009	3 00	.2058 x .2072	21.36	
		36.45	.020	.003	.017	2 40		37.71	

		44.48	.030	.0085	.0215	2 15	....	46.01	
		48.11	.040	.0165	.0235	4 30	....	49.77	
		48.11	.043	(Broke.)	....	0 05	....	49.77	Broke on re-applying this strain. Seam to the center.
1306	T co 16 * TEMPERED ..	20.50	.010	.0015	.0085	2 06	.2964 x .2958	21.32	
		36.00	.020	.005	.015	2 00	....	37.44	Two seams about 0″.1 deep. Broke suddenly when torsion seemed to have nearly ceased.
		48.65	.030	(Broke.)	....	2 45	....	50.59	
1307	A co 91 TEMPERED	24.65	.010	.0015	.0085	3 40	.2981 x .3009	24.77	
		48.40	.020	.0035	.0165	3 00	....	48.64	
		60.00	.030	.0095	.0205	3 00	....	60.30	
		64.62	.040	.0175	.0225	4 10	....	64.94	
		67.05	.050	.0265	.0235	4 20	....	67.38	
		70.00	.070	.0445	.0255	5 00	....	70.35	
		71.16	.083	.057	.026	6 00	....	71.51	
		71.70	.090	.064	.026	6 00	....	72.05	
		72.50	.1045	.0775	.0270	7 30	....	72.86	Raised 72.50 pounds before reaching torsion of 0″.1.
		72.95	.1110	.084	.0270	3 00	....	73.31	
		73.50	.123	.0955	.0275	3 30	....	73.86	
		73.80	.130	.1035	.0265	2 50	....	74.16	
		74.20	.142	.1145	.0275	6 00	....	74.57	
		74.40	.1525	.125	.0275	6 00	....	74.77	
		74.76	.162	.134	.028	5 30	....	75.13	A slight seam seen on one side.
		74.86	.170	.143	.027	4 00	....	75.23	After standing, released, until morning, torsion was 0.142.
		76.70	.2175	.1885	.0290	2 00	....	77.08	
		77.25	.230	.2015	.0285	10 00	....	77.63	The strain of 76.70 pounds was reached before torsion of 0.18.
		77.35	.243	.2135	.0295	13 00	....	77.73	
		77.87	.260	.231	.029	11 00	....	78.25	
		77.90	.270	.241	.029	8 30	....	78.28	
		78.30	.280	.2515	.0285	7 20	....	78.69	
		78.40	.290	.261	.029	5 00	....	78.79	
		78.60	.3035	.2745	.0290	8 30	....	78.99	
		78.75	.315	.2855	.0295	11 00	....	79.14	
		79.30	.330	.301	.029	16 00	....	79.69	
		79.35	.340	.311	.029	10 00	....	79.74	
		79.60	.350	.3205	.0295	5 30	....	79.99	
		79.81	.360	.331	.029	6 00	....	80.20	
		79.90	.370	.340	.030	4 15	....	80.29	
		80.05	.380	.351	.029	6 30	....	80.45	
		80.20	.390	.360	.030	7 30	....	80.60	
		80.40	.400	.3705	.0295	6 40	....	80.80	
		80.90	.410	.381	.029	5 35	....	81.30	
		81.02	.420	.391+	.029	4 00	....	81.42	
		81.70	.4415	.412	.0295	14 00	....	82.10	
		81.75	.4600	.430	.030	7 30	....	82.15	
		81.85	.472	.442	.030	5 30	....	82.25	
		82.07	.493	(Broke.)	....	11 35	....	82.48	After yielding very slowly at this strain it broke suddenly.

TABLE 29.—*TORSIONAL TESTS of tempered gun-wires*—Continued.

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0″.3 x 0″.3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
1308	A co 138 TEMPERED ...	20. 15	.010	.0025	.0075	4 25	.2983 x .2972	20. 60	
		37. 00	.020	.0065	.0135	2 00	....	37. 84	
		49. 06	.030	.0115	.0185	2 15	....	50. 17	
		53. 00	.040	.0200	.020	6 30	....	54. 20	
		55. 15	.050	.029	.021	5 00	....	56. 40	
		56. 55	.060	.0385	.0215	6 40	....	57. 83	
		57. 80	.070	.0485	.0215	3 05	....	59. 11	
		58. 55	.080	.058	.022	4 05	....	59. 88	
		59. 80	.100	.077	.023	12 00	....	61. 16	
		61. 05	.120	.0965	.0235	16 30	....	62. 44	After standing over night raised 61. 05 pounds before beginning to stretch.
		61. 33	.130	.107	.023	13 00	....	62. 72	
		61. 70	.140	.1165	.0235	15 00	....	63. 10	
		61. 95	.150	.126	.024	7 32	....	63. 36	
		62. 25	.160	.137	.023	7 45	....	63. 66	
		62. 60	.171	.148	.023	7 30	....	64. 02	
		63. 20	.196	.171	.025	20 00	....	64. 64	
		63. 75	.210	.189	.021	8 30	....	65. 20	
		63. 85	.224	.199	.025	8 35	....	65. 30	
		64. 40	.242	.218	.024	12 00	....	65. 86	
		64. 80	.260	.236	.024	7 00	....	66. 27	
		64. 90	.270	.2465	.0235	4 15	....	66. 37	
		65. 00	.280	.2565	.0235	4 45	....	66. 48	
		65. 25	.290	.2665	.0235	5 00	....	66. 73	
		65. 40	.302	.278	.024	6 30	....	66. 89	
		65. 55	.310	.286	.024	5 00	....	67. 04	
		65. 65	.320	.2965	.0235	12 30	....	67. 14	
		66. 60	.360	.336	.024	17 30	....	68. 11	
		66. 90	.374	.3495	.0245	30 00	....	68. 42	
		68. 40	.460	.435	.025	24 30	....	69. 95	
		70. 00	.578	.552	.016	22 30	....	71. 59	
		71. 15	.710	.6845	.0255	22 30	....	72. 77	
		73. 00	.834	(Broke.)	....	1 00	....	74. 66	

1309	H co 1 * TEMPERED...	20.45	.010	.0005	.0095	2 00	.3005 x .2955	20.96	Split in hardening.
		42.25	.020	.0015	.0185	3 05	....	43.10	
		59.56	.030	.006	.024	2 50	....	60.76	
		68.50	.040	.0115	.0285	3 00	....	69.88	
		73.30	.050	.018	.032	3 00	....	74.78	
		76.00	.064	.0285	.0355	3 00	....	77.53	Broke before raising this weight the second time.
1317	H W co 4 TEMPERED..	26.95	.012	.002	.010	2 00	.2991 x .2975	27.41	
		35.81	.020	.0065	.0135	2 40	....	36.42	
		39.65	.031	.0155	.0155	5 25	....	40.33	
		42.55	.0535	.035	.0185	4 00	....	43.28	
		43.40	.064	.0465	.0175	6 30	....	44.14	
		44.65	.085	.0665	.0185	4 00	....	45.41	
		45.40	.100	.081	.019	5 25	....	46.17	Seams on two sides. A crack opening.
		48.75	.210	.190	.020	11 00	....	49.59	
		50.15	.250	.231	.019	4 00	....	51.01	
		51.65	.290	.271	.019	4 10	....	52.52	
		53.25	.350	.334	.016	3 00	....	54.16	
		55.10	.4175	.3975	.020	5 00	....	56.04	
		57.55	.455	.435	.020	6 00	....	58.53	
		59.88	.564	(Broke.)	....	0 30	....	60.90	Broke near center of specimen.
1318	B S co 5 * TEMPERED.	25.35	.010	.001	.009	2 15	.3005 x .298	25.52	
		32.35	.021	.009	.012	2 30	....	32.57	
		33.35	.031	.019	.012	2 45	....	33.58	
		34.20	.040	.028	.012	3 00	....	34.44	
		35.00	.050	.0375	.0125	3 00	....	35.24	
		36.00	.060	.047	.013	4 00	....	36.25	
		36.85	.073	.059	.014	6 00	....	37.11	
		37.46	.082	.068	.014	5 30	....	37.72	
		38.10	.092	.0775	.0145	4 00	....	38.37	
		38.75	.103	.088	.015	4 00	....	39.02	
		41.05	.1515	.137	.0145	13 30	....	41.34	
		42.90	.200	.184	.016	14 00	....	43.20	
		44.50	.252	.236	.016	10 15	....	44.81	
		46.05	.3075	.290	.0175	9 00	....	46.37	
		47.05	.351	.334	.017	9 00	....	47.38	
		48.25	.411	.3935	.0175	21 00	....	48.59	
		49.10	.460	.443	.017	17 00	....	49.44	
		49.80	.502	.484	.018	17 15	....	50.15	
		50.60	.550	.532	.018	10 00	....	50.95	
		51.25	.619	(Broke.)	....	6 45	....	51.61	
1319	C K TEMPERED........	17.70	.010	.0015	.0085	2 00	.297 x .2969	18.25	A seam was visible before the specimen was put into the machine.
		29.20	.020	.005	.015	3 00	....	30.10	
		33.15	.0305	.013	.0175	3 30	....	34.18	
		36.20	.050	.0305	.0195	5 20	....	37.32	
		37.00	.060	.0395	.0205	2 00	....	38.15	

TABLE 29.—*TORSIONAL TESTS of tempered gun-wires*—Continued.

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0″.3 x 0″.3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
1319	C K TEMPERED—Cont'd	38.11	.071	.0505	.0205	5 00	....	39.29	
		38.80	.083	.062	.027	3 30	....	40.00	
		40.40	.110	.089	.021	3 10	....	41.65	
		42.20	.150	.1285	.0215	2 40	....	43.51	
		44.20	.200	.178	.022	4 00	....	45.57	
		45.90	.253	.230	.023	5 45	....	47.32	
		46.25	.260	.2385	.0215	2 15	....	47.68	
		47.00	.292	.2695	.0225	6 35	....	48.46	
		48.00	.320	.2985	.0215	5 05	....	49.49	
		48.75	.350	.3285	.0215	5 30	....	50.26	
		50.45	.400	.3785	.0215	7 00	....	52.01	
		53.80	.503	.480	.023	3 00	....	55.47	
		55.10	.560	.5375	.0225	6 30	....	56.81	Cross-line separated about 0″.1.
		56.29	.583	(Broke.)	....	15	....	58.04	
1320	T co 12 * TEMPERED ..	21.63	.01	.001	.009	3 00	.235 x .2964	22.57	
		34.25	.02	.0065	.0135	2 25	....	35.74	
		37.40	.03	.0135	.0165	2 00	....	39.03	
		39.40	.0425	.0245	.0180	2 00	....	41.12	
		40.75	.052	.0335	.0185	2 30	....	42.53	
		41.70	.061	.0425	.0185	4 20	....	43.52	At this strain an oblique crack was made from corner to corner on one side.
		42.65	.072	.0520	.020	6 00	....	44.51	
		43.20	.080	.060	.020	3 10	....	45.08	
		44.00	.090	.070	.020	2 00	....	45.92	
		45.25	.1475	(Broke.)	....	4 45	....	47.22	
1321	A co 91 TE RRED....	22.60	.010	.0015	.0085	2 45	.2996 x .2961	23.09	
		37.00	.020	.0055	.0135	3 00	....	37.80	
		40.32	.032	.0165	.0155	5 35	....	41.19	
		41.32	.0425	.027	.0155	3 40	....	42.22	
		42.40	.0500	.0335	.0165	4 15	....	43.32	
		43.50	.060	.0415	.0155	6 45	....	44.44	
		44.20	.070	.0535	.0165	4 00	....	45.16	

		45.30	.084	.066	.018	4 00	....	46.28	
		46.50	.1005	.0825	.0180	5 45	....	47.51	
		49.65	.152	.133	.019	14 00	....	50.73	
		51.70	.200	.181	.019	14 00	....	52.82	
		53.45	.250	.231	.019	7 10	....	54.61	
		55.00	.300	.280	.020	6 30	....	56.19	
		56.52	.361	.340	.021	11 30	....	57.75	
		58.12	.430	.409	.021	8 10	....	59.38	
		60.55	.540	.518	.022	19 00	....	61.86	
		61.55	.625	.6015	.0235	19 30	....	62.89	
		62.10	.6715	.649	.0225	18 15	....	63.45	
		62.63	.7335	.7115	.022	28 00	....	63.99	
		63.00	.745	(Broke.)	....	2 20	....	64.37	
1322	A co 138 TEMPERED...	23.80	.010	.0015	.0085*	6 00	.2982 x .298	24.26	
		34.85	.020	.0065	.0135	4 00	....	35.53	
		36.85	.030	.017	.013	2 00	....	37.57	
		38.00	.044	.029	.015	3 00	....	38.74	
		38.75	.0515	.0375	.0140	4 40	....	39.50	
		39.45	.060	.045	.015	5 20	....	40.22	
		40.20	.070	.056	.014	7 00	....	40.98	
		40.90	.0801	.066	.0141	11 30	....	41.70	
		41.70	.095	.079	.016	13 30	....	42.51	
		42.16	.100	.084	.016	8 20	....	42.98	
		43.17	.120	.104	.016	8 40	....	44.01	
		44.00	.136	.119	.017	6 30	....	44.86	
		44.55	.142	.1255	.0165	7 30	....	45.42	
		45.00	.157	.139	.018	7 25	....	45.88	
		45.75	.176	.159	.017	9 10	....	46.64	
		46.15	.1865	.169	.0175	6 30	....	47.05	
		46.50	.195	.178	.017	10 30	....	47.41	
		47.15	.218	.201	.017	11 00	....	48.07	
		47.85	.240	.223	.017	20 00	....	48.78	
		49.60	.301	.2835	.0175	25 00	....	50.57	
		51.00	.359	.340	.019	9 30	....	51.99	
		52.00	.408	.3895	.0185	10 30	....	53.01	
		53.00	.466	.447	.019	10 00	....	54.03	
		53.85	.525	.506	.019	17 20	....	54.90	
		55.50	.623	.6035	.0195	21 30	....	56.58	
		55.95	.679	.659	.020	29 00	....	57.04	
		57.25	.700	(Broke.)	....	9 35	....	58.37	After yielding very slowly for a few minutes it began to stretch more rapidly and soon broke.
1323	H co 1 ⁂ TEMPERED...	16.80	.010	.002	.008	2 05	.2951 x .2962	17.54	A seam visible before putting into the machine.
		30.75	.020	.0045	.0155	5 30	....	32.11	
		36.00	.030	.0115	.0185	4 00	....	37.59	
		38.85	.040	.0195	.0205	4 20	....	40.57	
		40.90	.050	.0290	.0210	4 00	....	42.71	

*About.

TABLE 29.—*TORSIONAL TESTS of tempered gun-wires*—Continued.

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0''.3 x 0''.3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
1323	H co 1 * TEMPERED—Continued.	42.30	.060	.038	.022	3 30	....	44.17	
		44.00	.0725	.049	.0235	4 45	....	45.95	
		44.70	.080	.0565	.0235	4 00	....	46.68	
		45.85	.090	.0665	.0235	8 00	....	47.88	
		46.40	.100	.076	.024	4 00	....	48.46	
		47.40	.1145	.088	.0265	5 40	....	49.50	
		48.50	.134	.109	.025	5 00	....	50.65	
		49.65	.150	.124	.026	2 20	....	51.85	
		50.00	.166	.1395	.0265	4 15	....	52.22	
		50.00	.176	(Broke.)	....	20	....	52.22	Seam separated cross-line about 0''.04.

TABLE 30.—*TORSIONAL TESTS of specimens of tool-steel (best cast-steel) procured at the agencies of the manufacturers.*

[For explanation of marks see pages 136 to 140, inclusive.]

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0″.3 x 0″.3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
1337	E M co 1*	18.19	.0115	.0035	.0080	2 00	.2981 x .2963	18.71	
		39.00	.100	.079	.021	1 00		40.12	
		46.71	.200	.179	.021	0 30		48.04	
		48.84	.2735	(Broke.)		0 10		50.24	
1338	E M co 2*	14.45	.012	.0035	.0065	2 30	.2977 x .301	14.45	
		29.84	.100	.082	.018	0 45		30.02	
		37.40	.200	.180	.020	0 28		37.63	
		40.40	.2555	(Broke.)		0 10		40.65	
1339	H W co T*	21.36	.010	.0015	.0085	3 00	.301 x .300	20.25	
		49.38	.100	.0755	.0245	1 45		49.14	
		59.50	.200	.1715	.0285	0 30		59.21	
		62.30	.2715	(Broke.)		0 15		61.99	
1340	N co T 1*	20.00	.011	.003	.008	3 00	.299 x .300	20.10	
		41.50	.100	.080	.020	1 00		41.70	
		49.96	.200	.178	.022	0 30		50.20	
		53.61	.300	.2785	.0215	0 20		53.87	
1341	N co T 2*	19.30	.010	.002	.008	2 30	.3003 x .2994	19.32	
		41.98	.100	.0805	.0195	1 00		42.04	
		50.52	.200	.1785	.0215	0 35		50.59	
		54.19	.300	.278	.0022	0 12		54.27	
1342	S B co I*	18.25	.010	.0025	.0075	2 30	.3006 x .2985	18.33	
		36.97	.100	.0825	.0175	1 00		37.13	
		44.74	.200	.1815	.0185	0 30		44.94	
		48.00	.300	.2795	.0205	0 20		48.21	
		48.75	.332	(Broke.)		0 05		48.97	

TABLE 30.—*TORSIONAL TESTS of specimens of tool-steel*—Continued.

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Resilience.	Time of twisting.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0''.3 x 0''.3.	Remarks.
No. of experiment.	Material.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*Turns.*	*m. s.*	*Inches.*	*Lbs.*	
1343	S B co 2*	17.00	.0175	.009	.0085	3 45	.2961 x .2981	17.50	
		34.44	.100	.0835	.0165	0 50	....	35.45	
		41.45	.200	.182	.018	0 25	....	42.67	
		44.45	.300	.282	.018	0 15	....	45.76	
		45.27	.3455	(Broke.)	....	0 04	....	46.60	
1344	J co 1*...............	14.50	.010	.0035	.0065	2 00	.3005 x .2987	14.92	
		35.08	.100	.0835	.0165	0 50	....	36.10	
		41.87	.200	.1805	.0195	0 20	....	43.08	
		44.74	.310	.2935	.0165	0 15	....	46.04	
1345	J co 2	15.04	.017	.009	.008	3 30	.2963 x .298	15.47	
		31.73	.100	.086	.014	0 40	....	32.65	
		38.36	.200	.184	.016	0 20	....	39.47	
		41.64	.300	.282	.018	0 23	....	42.85	
		42.88	.373	(Broke.)	....	0 05	....	44.12	
1346	J B H co*............	15.00	.010	.0035	.0065	4 12	.2989 x .3004	15.04	
		31.75	.100	.0867	.0133	4 30	....	31.85	
		39.40	.207	.1905	.0165	5 00	....	39.52	
		43.10	.303	.286	.017	4 25	....	43.23	
		45.18	.3555	(Broke.)	....	1 30	....	45.32	
1347	H *	18.35	.010	.002	.008	3 00	.297 x .2984	18.77	
		37.00	.100	.0825	.0165	0 48	....	37.86	
		45.33	.200	.1815	.0185	0 22	....	46.38	
		49.44	.300	.280	.020	0 18	....	51.49	
		50.15	.335*	(Broke.)	....	0 05	....	51.31	
1348	H E co 2*............	15.35	.010	.0015	.0085	3 45	.2966 x .2984	15.68	
		30.10	.100	.080	.020	0 50	....	30.75	
		38.65	.200	.1785	.0215	0 30	....	39.48	
		44.44	.300	.2775	.0225	0 20	....	45.39	
		46.61	.368	(Broke.)	....	0 08	....	47.61	

1349	E M co 2*	16.45	.010	.0035	.0065	3 15	.2977 x .300	16.34
		32.40	.100	.087	.013	0 50		32.76
		40.00	.200	.185	.015	0 20		40.44
		44.00	.300	.2835	.0165	0 20		44.49
		46.90	.400	.3825	.0175	0 16		47.32
		47.49	.439	(Broke.)		0 06		48.02
1350	H E co 2*	19.50	.010	.0025	.0075	3 30	.2986 x .3007	19.56
		37.00	.100	.085	.015	1 55		37.12
		45.67	.200	.1835	.0165	0 20		45.87
		49.91	.300	.2825	.0175	0 18		50.06
		51.00	.355	(Broke.)		0 05		51.16
1351	J B H co*	16.70	.010	.003	.007	5 00	.3007 x .2984	16.76
		34.98	.100	.0855	.0145	0 50		35.11
		42.66	.200	.1835	.0165	0 25		42.81
		46.87	.300	.281	.019	0 20		47.04
		50.00	.400	.3805	.0195	0 15		50.18
		50.77	.4385	(Broke.)		0 05		50.95

About.

TABLE 31.—*Experiment to determine the resistance, elasticity, and endurance under reversed torsions of a gun-wire drawn from crucible cast-steel manufactured by the Atlantic Steel-Works.*

[Mark, A co 138; size, 0''.2978 x 0''.2971.—Experiment No. 1262.]

Number of application.	Torsion to the left.				Torsion to the right.			Remarks.
	Decimal part of one turn.	Strain required 1 foot from center.	Time in which torsion was produced.	Resilience.	Decimal part of one turn.	Time in which torsion was produced.	Resilience.	
		Lbs.	*m. s.*	*Turns.*		*m. s.*	*Turns.*	
1	0.1	25.24	4 00	.010	0.1	0 30	.005	Specimen annealed at a heat between the melting-points of bronze and copper.
2	0	29.00						
	0.1	33.10	5 30	.011	0.1	0 30	.010	
3	0	30.60						
	0.1	34.20	6 10	.0125	0.1	0 30	.0105	Length, 1 inch.
4	0	31.25						
	0.1	34.95	7 00	.012–	0.1	0 30	.011	Each return to the extreme of left-hand torsion was made with sufficient allowance of time to obtain very nearly the whole extent of torsion that would result from the continuance of the strain given.
5	0	31.50						
	0.1	35.17	4 00	.012	0.1	0 30	.011	
6	0	31.40						
	0.1	35.15	4 30	.0125	0.1	0 30	.011	
7	0	31.30						
	0.1	35.08	8 00	.013	0.1	0 30	.011–	
8	0	31.35						
	0.1	35.30	8 30	.013	0.1	0 30	.011–	
9	0	31.40						
	0.1	35.30	7 00	.013	0.1	0 30	.011–	
10	0	31.40						
	0.1	35.30	10 30	.013	0.1	0 30	.011–	
11	0	31.30						
	0.1	35.28	5 30	.013	0.1	0 30	.011–	
12	0	31.34						
	0.1	35.35	6 00	.013	0.1	0.30	.011–	
13	0	31.30						
	0.1	35.30	5 40	.013	0.1	0 30	.011–	
14	0	31.30						
	0.1	35.35	6 00	.013	0.1	0 30	.011–	
15	0	31.25						
	0.1	35.30	5 00	.013	0.1	0 30	.0115	
16	0	31.65						After standing 15 hours.
	0.1	35.80	8 30	.013	0.1	0 30	.0115	
17	0	31.47						
	0.1	35.65	7 30	.0135	0.1	0 30	.0115	
18	0	31.32						
	0.1	35.55	7 00	.0135	0.1	0 30	.0115	
19	0	31.30						
	0.1	35.54	6 30	.013	0.1	0 30	.0115	
20	0	31.11						
	0.1	35.43	5 00	.0135	0.1	0 30	.0115	
21	0	31.00						
	0.1	35.37	7 00	.0135	0.1	0 30	.0115	
22	0	30.95						
	0.1	35.20	6 45	.0135	0.1	0 30	.0115	
23	0	30.90						
	0.1	35.20	7 30	.013	0.1	0 30	.0115	
24	0	30.65						After an intermission of about 4½ hours.
	0.1	35.20	7 30	.0135	0.1	0 30	.0115	
25	0	30.78						
	0.1	35.00	6 00	.0135	0.1	0 30	.0115	
26	0	30.62						
	0.1	35.00	9 00	.0135	0.1	0 30	.0115	
27	0	30.42						
	0.1	34.85	7 30	.0135	0.1	0 30	.0115	
28	0	30.30						
	0.1	34.75	6 10	.0135	0.1	0 30	.0115	
29	0	30.00						
	0.1	34.55	6 45	.0135	0.1	0 30	.0115	
30	0	29.95						
	0.1	34.40	5 00	.0135	0.1	0 30	.0115	
31	0	29.95						After standing 15 hours.
	0.1	34.45	7 30	.0135	0.1	0 30	.0115	
32	0	29.45						
	0.1	34.10	5 10	.0135	0.1	0 30	.012	
33	0	29.05						
	0.1	33.64	6 20	.0135	0.1	0 30	.012–	

TABLE 31.—*Experiment to determine the resistance, &c., of a gun-wire drawn from crucible cast-steel manufactured by the Atlantic Steel-Works*—Continued.

Number of application.	Torsion to the left.				Torsion to the right.			Remarks.
	Decimal part of one turn.	Strain required 1 foot from center.	Time in which torsion was produced.	Resilience.	Decimal part of one turn.	Time in which torsion was produced.	Resilience.	
		Lbs.	*m. s.*	*Turns.*		*m. s.*	*Turns.*	
34	0	28.64						
	0.1	33.20	5 05	.0135	0.1	0 30	.012	
35	0	28.00						
	0.1	32.75	6 45	.0135	0.1	0 30	.012—	
36	0	27.50						
	0.1	32.30	8 00	.0135	0.1	0 30	.012—	
37	0	26.97						
	0.1	31.95	9 45	.014	0.1	0 30	.012	
38	0	26.45						
	0.1	31.50	9 30	.035	0.1	0 30	.012	
39	0	25.70						
	0.1	30.79	6 00	.0135	0.1	0 30	.012	
40	0	25.05						
	0.1	30.15	9 00	.0135	0.1	0 30	.012	
41	0	24.15						
	0.1	29.75	8 30	.014	0.1	0 30	.012	
42	0	23.35						
	0.1	29.08	8 30	.014	0.1	0 30	.012	A crack discovered, chiefly longitudinal, and partly obliquely transverse.
43	0	22.60						
	0.1	28.25	6 00	.014	0.1	0 30	.012—	
44	0	21.65						
	0.1	27.55	6 20	.014	0.1	0 30	.012—	
45	0	20.50						
	0.1	26.92	6 00	.0145	0.1	0 30	.012	
46	0	19.50	....	....	......	......	....	After intermission of 1 hour.
	0.1	26.25	8 30	.015	0.1	0 30	.0125	A loud "tick" heard; crack enlarged.
47	0	18.25	....	....	......	......	....	Rupture extended to adjoining side.
	0.1	25.30	5 00	.0145	0.1	0 30	.013	
48	0	16.60	....	....	......	......	....	Each of the sides shows rupture.
	0.1	22.83	8 00	.014	0.1	0 30	.013	
49	0	13.60						
	0.1	15.60	0 30	.060	......	......	(Broke.)	

TABLE 32.—*Experiment to determine the resistance, elasticity, and endurance under reversed torsions of a gun-wire drawn from crucible cast-steel manufactured by James R. Thompson & Co.*

[Mark, T co 5; size, 0''.301 x 0''.302.—Experiment No. 126

Number of application.	Torsion to the left.				Torsion to the right.			Remarks.
	Decimal part of one turn.	Strain required 1 foot from center.	Time in which torsion was produced.	Resilience.	Decimal part of one turn.	Time in which torsion was produced.	Resilience.	
		Lbs.	*m. s.*	*Turns.*		*m. s.*	*Turns.*	
1	0.1	42.65	7 00	.018	0.1	1 00	.017—	Specimen annealed at a heat between the melting points of bronze and copper. Length, 1 inch. Each return to the extreme of left-hand torsion was made with sufficient allowance of time to obtain very nearly the whole extent of torsion that would result from the continuance of the strain given.
2	0	32.95						
	0.1	45.60	8 00	.0185	0.1	0 30	.017—	
3	0	33.00						
	0.1	45.60	10 00	.019	0.1	0 45	.017—	
4	0	32.87						
	0.1	45.60	9 30	.019	0.1	0 30	.017—	
5	0	32.83						
	0.1	45.50	8 00	.019	0.1	0 30	.017—	
6	0	32.80						
	0.1	45.50	7 30	.019	0.1	0 30	.017—	
7	0	32.60						
	0.1	45.10	7 30	.019	0.1	0 30	.017—	
	0	32.27	....	....	....	....	....	After intermission of 1 hour.
	0.1	44.65	7 00	.019	0.1	0 30	.0175	
9	0	32.00						
	0.1	44.12	6 30	.019	0.1	0 30	.017—	
10	0	31.50						
	0.1	43.61	8 00	.019	0.1	0 30	.017—	
11	0	30.60						
	0.1	42.80	7 30	.019	0.1	0 30	.0165	
12	0	30.00						
	0.1	42.40	7 00	.019	0.1	0 30	.017—	
13	0	29.25						
	0.1	41.55	6 30	.019	0.1	0 30	.017—	
14	0	28.55						
	0.1	40.85	7 00	.019	0.1	0 30	.017—	
15	0	28.05						
	0.1	40.15	6 00	.019	0.1	0 30	.017—	
16	0	27.50						
	0.1	39.80	6 00	.0185	0.1	0 30	.017—	
17	0	26.98						
	0.1	39.20	6 30	.019	0.1	0 30	.0165	
18	0	26.50						
	0.1	38.60	6 00	.019	0.1	0 30	.016—	
19	0	25.90						
	0.1	38.25	5 30	.019	0.1	0 30	.0165	
20	0	25.50						
	0.1	37.50	5 30	.019	0.1	0 30	....	
21	0	25.00						
	0.1	37.12	4 40	.019	0.1	0 30	.017—	
22	0	24.25						
	0.1	36.20	4 30	.019	0.1	0 30	.017—	
23	0	23.40						
	0.1	35.50	5 00	.019	0.1	0 30	.017—	Cracking sound; a small split is found.
24	0	22.51						
	0.1	34.60	4 00	.019	0.1	0 20	.017—	
25	0	21.76						
	0.1	33.85	4 00	.019	0.1	0 40	.017—	
26	0	20.93						
	0.1	33.25	3 40	.0195	0.1	0 30	.017—	
27	0	20.30						
	0.1	32.40	4 00	.019	0.1	0 30	.017—	
28	0	19.50						
	0.1	31.80	3 45	.019	0.1	0 30	.017—	
29	0	18.70						
	0.1	30.95	4 00	.019	0.1	0 30	.017—	
30	0	17.90						
	0.1	30.00	3 30	.0195	0.1	0 30	.017—	
31	0	17.00						
	0.1	29.20	3 30	.019	0.1	0 30	.017—	
32	0	16.10						
	0.1	28.40	3 10	.020	0.1	0 30	.0175	

TABLE 32.—*Experiment to determine the resistance, &c., of a gun-wire drawn from crucible cast steel manufactured by James R. Thompson & Co.*—Continued.

Number of application.	Torsion to the left.				Torsion to the right.			Remarks.
	Decimal part of one turn.	Strain required 1 foot from center.	Time in which torsion was produced.	Resilience.	Decimal part of one turn.	Time in which torsion was produced.	Resilience.	
		Lbs.	*m. s.*	*Turns.*		*m. s.*	*Turns.*	
33	0	15.20						
	0.1	27.55	4 00	.020	0.1	0 30	.018—	
34	0	14.50						
	0.1	26.70	4 00	.020	0.1	0 30	.018—	
35	0	13.90						
	0.1	26.05	4 10	.021	0.1	0 30	.018—	
36	0	13.15						
	0.1	25.25	4 00	.021	0.1	0 30	.018—	
37	0	12.50						
	0.1	24.50	3 00	.021	0.1	0 30	.018—	
38	0	11.81						
	0.1	23.50	3 30	.021	0.1	0 30	.018—	
39	0	11.00						
	0.1	22.30	3 00	.021	0.1	0 30	.0175	
40	0	10.00	....	....	0.1	0 30	.011—	Did not raise 20 pounds.
41	......	*	....	....	......	......	....	Broke without noise.

* Less than 1 pound.

TABLE 33.—*Experiment to determine the resistance, elasticity, and endurance under reversed torsions of a gun-wire drawn from chrome steel manufactured by the Chrome Steel Company.*

[Mark, C S co 5; size, 0″.2949 x 0″.2969.—Experiment No. 1264.]

Number of application.	Torsion to the left.				Torsion to the right.			Remarks.
	Decimal part of one turn.	Strain required 1 foot from the center.	Time in which torsion was produced.	Resilience.	Decimal part of one turn.	Time in which torsion was produced.	Resilience.	
		Lbs.	*m. s.*	*Turns.*		*m. s.*	*Turns.*	
1	0.1	29.70	8 00	.012—	0.1	0 30	.0115	Specimen annealed at a heat between the melting-points of bronze and copper.
2	0	29.50						
	0.1	35.40	5 30	.013	0.1	0 30	.011—	
3	0	29.90						
	0.1	35.90	6 30	.0135	0.1	0 30	.0115	Length, 1 inch.
4	0	30.00						
	0.1	36.30	6 30	.013	0.1	0 30	.0115	Each return to the extreme of left-hand torsion was made with sufficient allowance of time to obtain very nearly the whole extent of torsion that would result from the continuance of the strain given.
5	0	29.91						
	0.1	36.40	6 20	.013	0.1	0 30	.012—	
6	0	29.98						
	0.1	36.25	7 00	.0135	0.1	0 30	.012—	
7	0	29.95						
	0.1	36.40	7 00	.0135—	0.1	0 30	.0135	
8	0	30.90						
	0.1	37.20	9 00	.0135	0.1	0 30	.0115	After intermission of one day and two nights.
9	0	30.40						
	0.1	36.90	8 10	.0135	0.1	0 30	.012—	
10	0	30.10						
	0.1	36.67	8 30	.0135	0.1	0 30	.012—	
11	0	30.07						
	0.1	36.60	6 30	.0135	0.1	0 30	.012—	
12	0	30.07						
	0.1	36.53	7 15	.0135	0.1	0 30	.012—	
13	0	29.70						
	0.1	36.42	7 00	.0135	0.1	0 30	.012—	
14	0	29.50						
	0.1	36.00	9 00	.0135	0.1	0 30	.012—	
15	0	29.70						
	0.1	36.05	10 00	.0135	0.1	0 30	.012—	
16	0	29.07						
	0.1	35.90	6 25	.0135	0.1	0 30	.012—	
17	0	28.72						
	0.1	35.47	6 00	.014	0.1	0 30	.012	
18	0	28.25						
	0.1	35.20	4 10	.013	0.1	0 30	.012	
19	0	27.75						
	0.1	34.70	4 00	.0135	0.1	0 30	.012	
20	0	27.05	....	......	......	.....	......	After intermission of one night.
	0.1	34.05	5 00	.0135	0.1	0 30	.012—	
21	0	26.65						
	0.1	33.75	3 00	.014	0.1	0 30	.013—	
22	0	25.50						
	0.1	32.75	4 20	.015	0.1	0 30	.013	
23	0	24.15						
	0.1	31.55	13 00	.015	0.1	0 30	.013—	
24	0	22.65						
	0.1	30.00	4 00	.015	0.1	0 30	.013—	
25	0	20.25	....	....	......	......	....	Cracked badly.
	0.1	24.50	3 00	.0135	0.1	1 00	.0075	
26	−0.065	4.30						
	0	1.32						
	0.65	4.13	....	Broke.				

TABLE 34.—*Experiment to determine the resistance, elasticity, and endurance under reversed torsions of a gun-wire drawn from crucible cast steel manufactured by Benjamin Atha & Co.*

[Mark, N S co 4; size, 0''.2976 x 0''.2973.—Experiment No. 1265.]

Number of application.	Torsion to the left.				Torsion to the right.			Remarks.
	Decimal part of one turn.	Strain required 1 foot from center.	Time in which torsion was produced.	Resilience.	Decimal part of one turn.	Time in which torsion was produced.	Resilience.	
		Lbs.	*m. s.*	*Turns.*		*m. s.*	*Turns.*	
1	0.1	20.00	4 45	.0185	0.1	0 30	.008–	Specimen annealed at a heat between the melting-points of bronze and copper. Length, 1 inch. Each return to the extreme of left-hand torsion was made with sufficient allowance of time to obtain very nearly the whole extent of torsion that would result from the continuance of the strain given.
2	0	22.60						
	0.1	26.13	5 30	.010	0.1	0 30	.009–	
3	0	23.50						
	0.1	26.70	4 30	.011	0.1	0 30	.009	
4	0	23.60						
	0.1	26.80	12 00	.011	0.1	0 30	.009	
5	0	23.68						
	0.1	26.90	14 00	.011	0.1	0 30	.0095*	
6	0	24.20						
	0.1	27.67	7 15	.0115	0.1	0 30	.0095	
7	0	24.06						
	0.1	27.45	9 00	.0115	0.1	0 30	.0095	
8	0	24.00						
	0.1	27.40	6 00	.011	0.1	......	.000	
9	0	23.75						
	0.1	27.25	13 00	.012	0.1	0 30	.0095	
10	0	23.80						
	0.1	27.30	12 00	.0115	0.1	0 30	.0095	
11	0	23.80						
	0.1	27.30	10 50	.0115	0.1	0 30	.0095	
12	0	23.80						
	0.1	27.32	9 30	.012	0.1	0 30	.010–	
13	0	23.65						
	0.1	27.10	12 00	.0115	0.1	0 50	.010–	
14	0	23.73						
	0.1	27.40	9 10	.012	0.1	0 30	.0095	
15	0	23.60						
	0.1	27.25	9 15	.012–	0.1	0 30	.010	
16	0	23.60						
	0.1	27.27	10 30	.012–	0.1	0 30	.0095	
17	0	23.58*						
	0.1	27.25	12 00	.012	0.1	0 30	.0095	
18	0	23.51						
	0.1	27.15	11 30	.012	0.1	0 30	.0095	
19	0	23.53						
	0.1	27.20	12 00	.012	0.1	0 30	.010–	
20	0	23.40						
	0.1	27.17	7 00	.0115	0.1	0 30	.0095	
21	0	23.40						
	0.1	27.17	6 00	.012	0.1	0 30	.0095*	
22	0	23.65						
	0.1	27.38	11 00	.012	0.1	0 30	.0095	
23	0	23.37						
	0.1	27.25	11 00	.012	0.1	0 30	.0095	
24	0	23.30						
	0.1	27.15	10 00	.012	0.1	0 30	.0095	
25	0	23.13						
	0.1	27.00	10 00	.0115	0.1	0 30	.0095	
26	0	23.00						
	0.1	26.85	12 30	.0115	0.1	0 30	.010–	
27	0	22.87						
	0.1	26.70	8 00	.0115	0.1	0 30	.010–	
28	0	22.70						
	0.1	26.55	10 00	.0120	0.1	0 30	.010–	
29	0	22.60						
	0.1	26.50	7 30	.012–	0.1	0 30	.010–	
30	0	22.45						
	0.1	26.35	5 15	.0115	0.1	0 30	.010–	
31	0	22.25						
	0.1	26.10	6 00	.012	0.1	0 30	.010–	
32	0	22.00						
	0.1	25.90	5 15	.012	0.1	0 30	.010–	
33	0	21.77						
	0.1	25.75	6 00	.012	0.1	0 30	.010–	

* After intermission of about 15 hours.

TABLE 34.—*Experiment to determine the resistance, &c., of a gun-wire drawn from crucible cast steel manufactured by Benjamin Atha & Co.*—Continued.

Number of application.	Torsion to the left.				Torsion to the right.			Remarks.
	Decimal part of one turn.	Strain required 1 foot from center.	Time in which torsion was produced.	Resilience.	Decimal part of one turn.	Time in which torsion was produced.	Resilience.	
		Lbs.	*m. s.*	*Turns.*		*m. s.*	*Turns.*	
34	0	21.58						
	0.1	25.60	7 30	.0115	0.1	0 30	.0095	
35	0	21.40						
	0.1	25.40	5 10	.012	0.1	0 30	.010—	
36	0	21.15						
	0.1	25.13	7 00	.012	0.1	0 30	.010—	
37	0	20.90						
	0.1	24.95	5 00	.012	0.1	0 30	.010—	
38	0	20.75						
	0.1	24.65	5 15	.012	0.1	0 30	.010—	
39	0	20.40						
	0.1	24.42	6 00	.012	0.1	0 30	.010	
40	0	20.20						
	0.1	24.42	8 30	.012	0.1	0 30	.010	
41	0	20.00						
	0.1	24.88	5 15	.012--	0.1	0 30	.010—	
42	0	19.65						
	0.1	24.00	7 00	.012—	0.1	0 30	.010—	
43	0	19.42						
	0.1	23.45	6 10	.012—	0.1	0 30	.010—	
44	0	19.10						
	0.1	23.50	7 00	.012—	0.1	0 30	.010—	
45	0	18.88						
	0.1	23.00	5 00	.012—	0.1	0 30	.010—	
46	0	18.65						
	0.1	22.90	9 00	.012—	0.1	0.30	.010—	
47	0	18.45						
	0.1	22.65	6 10	.012	0.1	0 30	.010—	
48	0	18.07						
	0.1	22.15	7 30	.012	0.1	0 30	.0105	
49	0	17.85						
	0.1	21.97	5 00	.012	0.1	0 30	.010—	
50	0	17.60						
	0.1	21.82	6 00	.012	0.1	0 30	.0105	
51	0	17.35						
	0.1	21.65	6 40	.012	0.1	0 30	.011—	After standing over night.
52	0	17.35						
	0.1	21.62	7 00	.013	0.1	0 30	.011—	
53	0	16.95						
	0.1	21.35	8 10	.0125	0.1	0 30	.011—	
54	0	16.70						
	0.1	20.95	6 20	.0125	0.1	0 30	.011—	
55	0	16.40						
	0.1	20.70	5 30	.0125	0.1	0 30	.011—	
56	0	16.10						
	0.1	20.30	3 15	.013—	0.1	0 30	.011—	
57	0	15.75						
	0.1	20.15	3 15	.0125	0.1	0 30	.011—	
58	0	15.55						
	0.1	19.90	5 00	.013	0.1	0 30	.0105	
59	0	15.20						
	0.1	19.70	5 10	.013	0.1	0 30	.011—	
60	0	14.93						
	0.1	19.30	4 00	.013—	0.1	0 30	.011—	
61	0	14.62						
	0.1	19.25	4 00	.013—	0.1	0 30	.011--	
62	0	14.45						
	0.1	18.93	3 30	.0125	0.1	0 30	.011—	
63	0	14.17						
	0.1	18.55	6 00	.013—	0.1	0 30	.011—	
64	0	13.93						
	0.1	18.45	6 00	.013—	0.1	0 30	.011—	
65	0	13.75						
	0.1	18.12	4 00	.013—	0.1	0 30	.011—	
66	0	13.50						
	0.1	17.95	5 00	.0135	0.1	0 30	.011—	

TABLE 34.—*Experiment to determine the resistance, &c., of a gun-wire drawn from crucible cast steel manufactured by Benjamin Atha & Co.*—Continued.

Number of application.	Torsion to the left.				Torsion to the right.			Remarks.
	Decimal part of one turn.	Strain required 1 foot from center.	Time in which torsion was produced.	Resilience.	Decimal part of one turn.	Time in which torsion was produced.	Resilience.	
		Lbs.	*m. s.*	*Turns.*		*m. s.*	*Turns.*	
67	0	13.25						
	0.1	17.80	5 00	.0135	0.1	0 30	.0115	
68	0	13.30						
	0.1	18.00	7 00	.0135	0.1	0 30	.0115	After standing over night.
69	0	13.00						
	0.1	17.62	3 30	.0135	0.1	0 30	.0115	
70	0	12.75						
	0.1	17.25	5 00	.0135	0.1	0 30	.0115	
71	0	12.45						
	0.1	17.05	5 30	.0135	0.1	0 30	.0115	
72	0	12.35						
	0.1	16.85	5 00	.0135	0.1	0 30	.0115	
73	0	12.15						
	0.1	16.80	5 20	.0135	0.1	0 30	.0115	
74	0	11.95						
	0.1	16.56	5 00	.0135	0.1	0 30	.0115	
75	0	11.82						
	0.1	16.30	5 00	.0135	0.1	0 30	.012—	
76	0	11.62						
	0.1	16.00	4 00	.0135	0.1	0 30	.012—	
77	0	11.40						
	0.1	15.95	5 00	.0135	0.1	0 30	.012—	
78	0	11.30						
	0.1	15.78	4 00	.0135	0.1	0 30	.012—	
79	0	11.10						
	0.1	15.63	3 30	.014 —	0.1	0 30	.012—	
80	0	10.90						
	0.1	15.52	3 00	.0135	0.1	0 30	.012—	
81	0	10.85						
	0.1	15.40	5 30	.0135	0.1	0 30	.0125	
82	0	10.65						
	0.1	15.15	4 45	.0135	0.1	0 30	.0125	
83	0	10.55						
	0.1	14.97	5 00	.0135	0.1	0 30	.0125	
84	0	10.40						
	0.1	14.90	4 00	.0135	0.1	0 30	.013—	
85	0	10.15						
	0.1	14.72	3 30	.0135	0.1	0 30	.013—	
86	0	10.05						
	0.1	14.58	5 15	.014	0.1	0 30	.013—	
87	0	10.00						
	0.1	14.55	4 00	.0135	0.1	0 30	.013—	
88	0	9.85						
	0.1015	14.42	4 00	.014	0.1	0 30	.0135	Torsion accidentally .0015 too far.
89	0	9.94						
	0.1	14.47	7 00	.014	0.1	0 30	.013—	
90	0	9.57						
	0.1	14.12	4 00	.0135	0.1	0 30	.013—	
91	0	9.70						After intermission of about 20 hours.
	0.1	14.22	6 20	.015	0.1	0 30	.013—	Began to crack, probably at this turn.
92	0	9.38						
	0.1	13.90	4 00	.0145	0.1	0 30	.0135	
93	0	9.20						
	0.1	13.88	5 30	.015	0.1	0 30	.013—	
94	0	9.10						
	0.1	13.70	6 00	.0155	0.1	0 30	.013—	
95	0	8.94						After intermission of one night.
	0.1	13.55	6 00	.014	0.1	0 30	.0135	
96	0	8.90						
	0.1	13.60	4 30	.016	0.1	0 30	.013—	
97	0	8.75						Crack visibly enlarged.
	0.1	13.45	5 30	.0155	0.1	0 30	.0135	
98	0	8.55						
	0.1	13.20	5 20	.015	0.1	0 30	.0135	
99	0	8.45						
	0.1	13.18	8 30	.0145	0.1	0 30	.0135	

TABLE 34.—*Experiment to determine the resistance, &c., of a gun-wire drawn from crucible cast steel manufactured by Benjamin Atha & Co.*—Continued.

Number of application.	Torsion to the left.				Torsion to the right.			Remarks.
	Decimal part of one turn.	Strain required 1 foot from center.	Time in which torsion was produced.	Resilience.	Decimal part of one turn.	Time in which torsion was produced.	Resilience.	
		Lbs.	*m. s.*	*Turns.*		*m. s.*	*Turns.*	
34	0	21.58						
	0.1	25.60	7 30	.0115	0.1	0 30	.0095	
35	0	21.40						
	0.1	25.40	5 10	.012	0.1	0 30	.010—	
36	0	21.15						
	0.1	25.13	7 00	.012	0.1	0 30	.010—	
37	0	20.90						
	0.1	24.95	5 00	.012	0.1	0 30	.010—	
38	0	20.75						
	0.1	24.65	5 15	.012	0.1	0 30	.010—	
39	0	20.40						
	0.1	24.42	6 00	.012	0.1	0 30	.010	
40	0	20.20						
	0.1	24.42	8 30	.012	0.1	0 30	.010	
41	0	20.00						
	0.1	23.88	5 15	.012--	0.1	0 30	.010—	
42	0	19.65						
	0.1	24.00	7 00	.012—	0.1	0 30	.010—	
43	0	19.42						
	0.1	23.45	6 10	.012—	0.1	0 30	.010—	
44	0	19.10						
	0.1	23.50	7 00	.012—	0.1	0 30	.010—	
45	0	18.88						
	0.1	23.00	5 00	.012—	0.1	0 30	.010—	
46	0	18.65						
	0.1	22.90	9 00	.012—	0.1	0. 30	.010—	
47	0	18.45						
	0.1	22.65	6 10	.012	0.1	0 30	.010—	
48	0	18.07						
	0.1	22.15	7 30	.012	0.1	0 30	.0105	
49	0	17.85						
	0.1	21.97	5 00	.012	0.1	0 30	.010—	
50	0	17.60						
	0.1	21.82	6 00	.012	0.1	0 30	.0105	
51	0	17.35						
	0.1	21.65	6 40	.012	0.1	0 30	.011—	**After standing over night.**
52	0	17.35						
	0.1	21.62	7 00	.013	0.1	0 30	.011—	
53	0	16.95						
	0.1	21.35	8 10	.0125	0.1	0 30	.011—	
54	0	16.70						
	0.1	20.95	6 20	.0125	0.1	0 30	.011—	
55	0	16.40						
	0.1	20.70	5 30	.0125	0.1	0 30	.011—	
56	0	16.10						
	0.1	20.30	3 15	.013—	0.1	0 30	.011—	
57	0	15.75						
	0.1	20.15	3 15	.0125	0.1	0 30	.011—	
58	0	15.55						
	0.1	19.90	5 00	.013	0.1	0 30	.0105	
59	0	15.20						
	0.1	19.70	5 10	.013	0.1	0 30	.011—	
60	0	14.93						
	0.1	19.30	4 00	.013—	0.1	0 30	.011—	
61	0	14.62						
	0.1	19.25	4 00	.013—	0.1	0 30	.011--	
62	0	14.45						
	0.1	18.95	3 30	.0125	0.1	0 30	.011—	
63	0	14.17						
	0.1	18.55	6 00	.013—	0.1	0 30	.011—	
64	0	13.95						
	0.1	18.45	6 00	.013—	0.1	0 30	.011—	
65	0	13.75						
	0.1	18.12	4 00	.013—	0.1	0 30	.011—	
66	0	13.50						
	0.1	17.95	5 00	.0135	0.1	0 30	.011—	

TABLE 34.—*Experiment to determine the resistance, &c., of a gun-wire drawn from crucible cast steel manufactured by Benjamin Atha & Co.*—Continued.

Number of application.	Torsion to the left.				Torsion to the right.			Remarks.
	Decimal part of one turn.	Strain required 1 foot from center.	Time in which torsion was produced.	Resilience.	Decimal part of one turn.	Time in which torsion was produced.	Resilience.	
		Lbs.	*m. s.*	*Turns.*		*m. s.*	*Turns.*	
67	0	13.25						
	0.1	17.80	5 00	.0135	0.1	0 30	.0115	
68	0	13.30						
	0.1	18.00	7 00	.0135	0.1	0 30	.0115	After standing over night.
69	0	13.00						
	0.1	17.62	3 30	.0135	0.1	0 30	.0115	
70	0	12.75						
	0.1	17.25	5 00	.0135	0.1	0 30	.0115	
71	0	12.45						
	0.1	17.05	5 30	.0135	0.1	0 30	.0115	
72	0	12.35						
	0.1	16.85	5 00	.0135	0.1	0 30	.0115	
73	0	12.15						
	0.1	16.80	5 20	.0135	0.1	0 30	.0115	
74	0	11.95						
	0.1	16.56	5 00	.0135	0.1	0 30	.0115	
75	0	11.82						
	0.1	16.30	5 00	.0135	0.1	0 30	.012—	
76	0	11.62						
	0.1	16.00	4 00	.0135	0.1	0 30	.012—	
77	0	11.40						
	0.1	15.95	5 00	.0135	0.1	0 30	.012—	
78	0	11.30						
	0.1	15.78	4 00	.0135	0.1	0 30	.012—	
79	0	11.10						
	0.1	15.63	3 30	.014 —	0.1	0 30	.012—	
80	0	10.90						
	0.1	15.52	3 00	.0135	0.1	0 30	.012—	
81	0	10.85						
	0.1	15.40	5 30	.0135	0.1	0 30	.0125	
82	0	10.65						
	0.1	15.15	4 45	.0135	0.1	0 30	.0125	
83	0	10.55						
	0.1	14.97	5 00	.0135	0.1	0 30	.0125	
84	0	10.40						
	0.1	14.90	4 00	.0135	0.1	0 30	.013—	
85	0	10.15						
	0.1	14.72	3 30	.0135	0.1	0 30	.013—	
86	0	10.05						
	0.1	14.58	5 15	.014	0.1	0 30	.013—	
87	0	10.00						
	0.1	14.55	4 00	.0135	0.1	0 30	.013—	
88	0	9.85						
	0.1015	14.42	4 00	.014	0.1	0 30	.0135	Torsion accidentally .0015 too far.
89	0	9.94						
	0.1	14.47	7 00	.014	0.1	0 30	.013—	
90	0	9.57						
	0.1	14.12	4 00	.0135	0.1	0 30	.013—	
91	0	9.70	....	....	....	....	....	After intermission of about 20 hours.
	0.1	14.22	6 20	.015	0.1	0 30	.013—	Began to crack, probably at this turn
92	0	9.38						
	0.1	13.90	4 00	.0145	0.1	0 30	.0135	
93	0	9.20						
	0.1	13.88	5 30	.015	0.1	0 30	.013—	
94	0	9.10						
	0.1	13.70	6 00	.0155	0.1	[illegible]	[illegible]	
95	0	8.94	....	....	....	....	....	fter intermission of one night
	0.1	13.55	[illegible]	.014	0.1	[illegible]	[illegible]	
96	0	8.90						
	0.1	13.60	[illegible]	[illegible]	0.1	[illegible]	[illegible]	
97	0	8.75	[illegible]	[illegible]	....	[illegible]	[illegible]	rack visibly enlarged.
	0.1	13.4[illegible]	[illegible]	[illegible]	0.1	[illegible]	[illegible]	
98	0	[illegible]						
	0.1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
99	0	[illegible]						
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

TABLE 34.—*Experiment to determine the resistance, &c., of a gun wire drawn from crucible cast steel manufactured by Benjamin Atha & Co.*—Continued.

Number of application.	Torsion to the left.				Torsion to the right.			Remarks.
	Decimal part of one turn.	Strain required 1 foot from center.	Time in which torsion was produced.	Resilience.	Decimal part of one turn.	Time in which torsion was produced.	Resilience.	
		Lbs.	*m. s.*	*Turns.*		*m. s.*	*Turns.*	
100	0	8. 30						
	0. 1	13. 00	7 00	. 015	0. 1	0 30	. 0135	
101	0	8. 15						
	0. 1	12. 85	5 00	. 015	0. 1	0 30	. 0135	
102	0	8. 00						
	0. 1	12. 75	4 00	. 015	0. 1	0 30	. 0135	
103	0	7. 85						
	0. 1	12. 60	4 00	. 0155	0. 1	0 30	. 0135	
104	0	7. 68						
	0. 1	12. 40	4 00	. 015	0. 1	0 30	. 0135	
105	0	7. 55						
	0. 1	12. 35	4 00	. 015	0. 1	0 30	. 0135	
106	0	7. 35						
	0. 1	12. 15	3 50	. 015	0. 1	0 30	. 014—	
107	0	7. 20						
	0. 1	11. 90	3 00	. 015	0. 1	0 30	. 014—	
108	0	6 80						
	0. 1	11. 70	3 00	. 015	0. 1	0 30	. 0135	
109	0	6. 65						
	0. 1	11. 53	4 10	. 015	0. 1	0 30	. 0135	
110	0	6. 25						
	0. 1	11. 27	3 00	. 0145	0. 1	0 30	. 0135	
111	0	5. 95						
	0. 1	11. 05	3 00	. 0135	0. 1	0 30	. 014—	
112	0	5. 63						
	0. 1	10. 77	4 40	. 014	0. 1	0 30	. 0135	
113	0	5. 37						
	0. 1	10. 33	4 10	. 0135	0. 1	0 30	. 0135	
114	0	5. 10						
	0. 1	9. 95	3 00	. 0135	0. 1	0 30	. 013	
115	0	4. 85						
	0. 1	9. 70	3 00	. 0135	0. 1	0 30	. 0135	
116	0	4. 63						
	0. 1	9. 30	2 50	. 0135	0. 1	0 30	. 0135	
117	0	4. 35						
	0. 1	9. 10	3 00	. 0135	0. 1	0 30	. 0135	
118	0	4. 10						
	0. 1	8. 55	2 00	. 0135	0. 1	0 30	. 013—	
119	0	3. 82						
	0. 1	8. 53	3 00	. 0135	0. 1	0 30	. 013—	
120	0	3. 62						
	0. 1	(*)	3 10	. 013—	0. 1	0 30	. 013—	After standing through the dinner-hour.
121	0	3. 30						Would not raise 8 pounds.
	0. 1	7. 60	3 00	. 0135	0. 1	0 30	. 013—	
122	0	3. 15						
	0. 1	6 90	3 30	. 0135	0. 1	0 30	. 0135	
123	0	2. 88						
	0. 1	6. 61	3 20	. 0135	0. 1	0 30	. 0135	
124	0	2. 65						
	0. 1	6. 37	3 30	. 013	0. 1	0 30	. 0185	
125	0	2. 35						
	0. 1	6. 05	2 35	. 013	0. 1	0 30	. 0135	
126	0	2. 26						
	0. 1	5. 81	3 30	. 013	0. 1	0 30	. 0135	
127	0	2. 12						
	0. 1	5. 52	3 00	. 0125	0. 1	0 30	. 013—	
128	0	1. 98						
	0. 1	4. 87	2 55	. 012	0. 1	0 30	. 0135	
129	0	1. 77						
	0. 1	3. 95	3 30	. 0115	0. 1	0 30	. 0135	
130	0	1. 56						
	0. 1	3. 50	4 00	. 011	0. 1	0 30	. 012—	
131	.....	(*)	......	....	.....	.....	......	Would not raise 1.30 pounds.
	0. 1	3. 20	4 00	. 0115	0. 1	0 30	. 011—	

* Not taken.

TABLE 34.—*Experiment to determine the resistance, &c., of a gun-wire drawn from crucible cast steel manufactured by Benjamin Atha & Co.*—Continued.

Number of application.	Torsion to the left.				Torsion to the right.			Remarks.
	Decimal part of one turn.	Strain required 1 foot from center.	Time in which torsion was produced.	Resilience.	Decimal part of one turn.	Time in which torsion was produced.	Resilience.	
		Lbs.	*m. s.*	*Turns.*		*m. s.*	*Turns.*	
132	0	0.87						Sustained 0.87 pound a few moments and then dropped.
	0.1	2.23	4 00	.012	0.1	0 30	.008--	
133	0	0.30						
	0.1	1.58	3 00	.0085	0.1	0 30	.0075	
134	0	0.14						
	0.1	1.35	2 30	.0185	......	......	....	
	0.122	1.50	....	Failed.	......	......	....	Turning continued.
	0.264	....	....	Parted.	......	......	....	

TABLE 35.—*Experiment to determine the resistance, elasticity, and endurance under reversed torsions of a gun-wire drawn from crucible cast steel manufactured by the Atlantic Steel Works.*

[Mark, A oo 91; size, 0''.2986 x 0''.302.—Experiment No. 1266.]

Number of application.	Torsion to the left.				Torsion to the right.			Remarks.
	Decimal part of one turn.	Strain required 1 foot from center.	Time in which torsion was produced.	Resilience.	Decimal part of one turn.	Time in which torsion was produced.	Resilience.	
		Lbs.	*m. s.*	*Turns.*		*m. s.*	*Turns.*	
1	0.1	32.85	3 30	.011	0.1	0 30	.0115	Specimen annealed at a heat between the melting-points of bronze and copper. Length, 1 inch. Each return to the extreme of left-hand torsion was made with sufficient allowance of time to obtain very nearly the whole extent of torsion that would result from the continuance of the strain given.
2	0	34.10						
	0.1	41.20	7 00	.013	0.1	0 30	.012–	
3	0	35.52						
	0.1	42.35	6 40	.0135	0.1	0 30	.012–	
4	0	35.95						
	0.1	42.65	6 45	.0145	0.1	0 30	.013–	
5	0	36.00						
	0.1	42.87	7 00	.014	0.1	0 30	.013–	
6	0	36.00						
	0.1	43.00	9 20	.014	0.1	0 30	.013–	
7	0	35.90						
	0.1	42.98	5 00	.015	0.1	0 30	.013–	
8	0	35.90						
	0.1	42.95	9 10	.015	0.1	0 30	.013–	
9	0	35.90						
	0.1	42.95	9 10	.0145	0.1	0 30	.013–	
10	0	35.87						
	0.1	42.90	9 15	.015	0.1	0 30	.013–	
11	0	35.60						
	0.1	42.73	5 00	.014	0.1	0 30	.013–	
12	0	35.20						
	0.1	42.10	4 00	.015	0 1	0 30	.013–	
13	0	34.20						
	0.1	41.00	3 00	.014	0.1	0 30	.013–	
14	0	32.60						
	0.1	39.50	2 30	.014	0.1	0 30	.013–	
15	0	31.65						
	0.1	38.50	8 00	.015	0.1	0 30	.013–	
16	0	30.27						
	0.1	37.30	3 45	.015	0.1	0 30	.013–	
17	0	29.70						
	0.1	36.00	4 30	.013	0.1	0 30	.0135	Cracked loudly just before holding this weight; split, and transverse cracks visible.
18	0	28.20						
	0.1	31.60	4 40	.0145	0.1	0 30	.012	Several cracks heard in raising this weight.
19	0	23.00						
	0.020	23.30	....	(Broke.)	......	......	....	

TABLE 36.—*Experiment to determine the resistance, elasticity, and endurance under reversed torsions of a gun-wire drawn from Norway iron, (HΦS,) furnished by Messrs. Naylor & Co.*

[Mark, N oo I; square; size, 0''.2927 x 0''.2927.—Experiment No. 1267.]

Number of application.	Torsion to the left.				Torsion to the right.			Remarks.
	Decimal part of one turn.	Strain required 1 foot from center.	Time in which torsion was produced.	Resilience.	Decimal part of one turn.	Time in which torsion was produced.	Resilience.*	
		Lbs.	*m. s.*	*Turns.*		*m. s.*	*Turns.*	
1	0.1	14.20	... ...	.006	0.1	......	....	Specimen annealed at a heat between the melting-points of bronze and copper.
2	0	19.90						
	.120	22.35	....	.009	0.1	......	....	
3	0	22.60						
	0.1	24.35	....	.091	0.1	......	....	Length, 1 inch.
4	0	23.05						
	0.1	24.25	....	.0105	0.1	......	....	Each return to the extreme of left-hand torsion was made with sufficient allowance of time to obtain very nearly the whole extent of torsion that would result from the continuance of the strain given.
5	0	23.15						
	0.1	24.27	....	.0105	0.1	......	....	
6	0	22.70						
	0.1	24.40	....	.011—	0.1	......	....	
7	0	22.30						
	0.1	24.27	....	.011	0.1	......	....	
8	0	21.80						
	0.1	23.61	....	.011	0.1	......	....	
9	0	21.20						
	0.1	23.47	....	.011—	0.1	......	....	Stopped for the night.
10	0	21.70	... .	....	......	......	....	Resumed after 15 hours.
	0.1	24.25	....	.012	0.1	......	....	
11	0	(*)						
	0.1	23.30	....	.012	0.1	......	....	
12	0	19.50						
	0.1	22.60	....	.012—	0.1	......	....	
13	0	18.75						
	0.1	22.00	....	.012—	0.1	......	....	
14	0	18.10						
	0.1	21.58	....	.0125	0.1	......	....	
15	0	17.55						
	0.1	21.05	....	.0125	0.1	......	....	
16	0	16.95						
	0.1	20.45	....	.0125—	0.1	......	....	
17	0	16.35						
	0.1	20.00	....	.013	0.1	......	....	
18	0	15.80						
	0.1	19.25	....	.013	0.1	......	....	
19	0	15.35						
	0.1	19.07	....	.013	0.1	......	....	
20	0	14.87						
	0.1	18.60	....	.013	0.1	......	....	
21	0	14.40						
	0.1	18.15	....	.013	0.1	......	....	
22	0	13.96						
	0.1	17.75	....	.013	0.1	......	....	
23	0	13.70						
	0.1	17.50	....	.013	0.1	......	....	
24	0	13.35						
	0.1	17.05	....	.0135	0.1	......	....	
25	0	12.85						
	0.1	16.97	....	.0135	0.1	......	....	
26	0	12.55	....	....	......	......	....	A crack might probably have been discovered before this.
	0.1	16.62	....	.0135	0.1	......	....	
27	0	12.18						
	0.1	16.30	....	.0135	0.1	......	....	
28	0	12.00						
	0.1	16.05	....	.0135	0.1	.....	.... ..	
29	0	11.75						
	0.1	15.90	....	.014—	0.1	......	....	
30	0	11.48						
	0.1	15.57	....	.014	0.1	......	....	
31	0	11.90						
	0.1	15.00	....	.014	0.1	......	....	
32	0	11.00						
	0.1	14.95	....	.014	0.1	......	....	
33	0	10.83						
	0.1	14.95	....	.014	0.1	......	....	

* Not taken.

TABLE 36.—*Experiment to determine the resistance, &c., of a gun-wire drawn from Norway iron, (HΦS,) furnished by Messrs. Naylor & Co.*—Continued.

Number of application.	Torsion to the left.				Torsion to the right.			Remarks.
	Decimal part of one turn.	Strain required 1 foot from center.	Time in which torsion was produced.	Resilience.	Decimal part of one turn.	Time in which torsion was produced.	Resilience.*	
		Lbs.	*m. s.*	*Turns.*		*m. s.*	*Turns.*	
34	0	10.65						
	0.1	14.60	....	.014	0.1	......	....	
35	0	10.40						
	0.1	14.48	....	.014—	0.1	......	....	
36	0	10.30						
	0.1	14.00	....	.014	0.1	......	....	
37	0	10.00						
	0.1	14.00	....	.014	0.1	......	....	
38	0	9.95						
	0.1	13.75	....	.014—	0.1	......	....	
39	0	9.85	....	....	....	......	....	Badly cracked.
	0.1	13.62	....	.0145	0.1	......	....	
40	0	9.55						
	0.1	13.33	....	.0145	0.1	......	....	
41	0	9.45						
	0.1	13.30	....	.015	0.1	......	....	
42	0	9.25						
	0.1	13.20	....	.015	0.1	......	....	
43	0	9.20						
	0.1	12.95	....	.015	0.1	......	....	
44	0	9.00						
	0.1	12.75	....	.015	0.1	......	....	Stopped at dinner hour.
45	0	8.89	....	....	....	......	....	Resumed after 1 hour's intermission.
	0.1	12.67	....	.015	0.1	......	....	
46	0	8.75						
	0.1	12.33	....	.015	0.1	......	....	
47	0	8.72						
	0.1	12.55	....	.015—	0.1	......	....	
48	0	8.60						
	0.1	12.40	....	.015—	0.1	......	....	
49	0	8.50						
	0.1	12.40	....	.015—	0.1	......	....	
50	0	8.40						
	0.1	12.00	....	.015—	0.1	......	....	
51	0	8.30						
	0.1	11.90	....	.015—	0.1	......	....	
52	0	8.10						
	0.1	11.84	....	.015—	0.1	......	....	
53	0	8.00						
	0.1	11.65	....	.015	0.1	......	....	
54	0	8.15						
	0.1	11.80	....	.015	0.1	......	....	
55	0	7.82						
	0.1	11.63	....	.015—	0.1	......	....	
56	0	7.80						
	0.1	11.50	....	.015—	0.1	......	....	
57	0	7.70						
	0.1	11.00	....	.015—	0.1	......	....	
58	0	7.60						
	0.1	11.00	....	.016	0.1	......	....	
59	0	7.47						
	0.1	11.00	....	.016	0.1	......	....	
60	0	7.35						
	0.1	10.93	....	.016	0.1	......	....	
61	0	7.25						
	0.1	10.92	....	.016	0.1	......	....	
62	0	7.23						
	0.1	10.80	....	.016	0.1	......	....	
63	0	7.20						
	0.1	10.70	....	.016—	0.1	......	....	
64	0	7.50						
	0.1	11.25	....	.016—	0.1	......	....	
65	0	7.20						
	0.1	10.83	....	.016—	0.1	......	....	
66	0	7.10						
	0.1	10.83	....	.016	0.1	......	....	

* Not taken.

TABLE 36.—*Experiment to determine the resistance, &c., of a gun-wire drawn from Norway iron, (HΦS,) furnished by Messrs. Naylor & Co.*—Continued.

Number of application.	Torsion to the left.				Torsion to the right.			Remarks.
	Decimal part of one turn.	Strain required 1 foot from center.	Time in which torsion was produced.	Resilience.	Decimal part of one turn.	Time in which torsion was produced.	Resilience.*	
		Lbs.	*m. s.*	*Turns.*		*m. s.**	*Turns.*	
67	0	(*)						
	0.1	10.60	......	.0165	0.1	......	......	
68	0	6.89						
	0.1	10.55	......	.0165	0.1	......	......	
69	0	6.78						
	0.1	10.25	......	.0165	0.1	......	......	
70	0	6.70						
	0.1	10.65	......	.0165	0.1	......	......	
71	0	6.65						
	0.1	10.25	......	.0165	0.1	......	......	
72	0	6.50						
	0.1	10.00	......	.0165	0.1	......	......	
73	0	6.47						
	0.1	10.10	......	.0165—	0.1	......	......	
74	0	6.38						
	0.1	10.03	......	.0165—	0.1	......	......	
75	0	6.38						
	0.1	9.88	......	.0165—	0.1	......	......	
76	0	6.30						
	0.1	9.77	......	.0165—	0.1	......	......	
77	0	6.20						
	0.1	9.75	......	.0165—	0.1	......	......	
78	0	6.00						
	0.1	9.60	......	.0165	0.1	......	......	
79	0	6.10						
	0.1	9.58	......	.0165—	0.1	......	......	
80	0	6.05						
	0.1	9.55	......	.0165—	0.1	......	......	
81	0	5.90						
	0.1	9.50	......	.0165—	0.1	......	......	
82	0	5.90						
	0.1	9.19	......	.0165—	0.1	......	......	
83	0	5.98						
	0.1	9.55	......	.0165—	0.1	......	......	
84	0	5.80						
	0.1	9.33	......	.017—	0.1	......	......	
85	0	5.80						
	0.1	9.25	......	.017—	0.1	......	......	
86	0	5.68						
	0.1	9.00	......	.017—	0.1	......	......	
87	0	5.65						
	0.1	8.88	......	.017—	0.1	......	......	
88	0	5.55						
	0.1	9.00	......	.017—	0.1	......	......	
89	0	5.50						
	0.1	9.00	......	.017--	0.1	......	......	
90	0	5.95	......	......	......	......	......	After standing over one day.
	0.1	9.75	......	.019	0.1	......	......	
91	0	5.78	......	......	......	......	......	After standing one hour.
	0.1	9.61	......	......	0.1	......	......	
92	0	5.63						
	0.1	9.42	......	.018	0.1	......	......	
93	0	......						
	0.112	9.35	......	......	0.1	......	......	Torsion carried by mistake to 0.112.
94	0	5.40						
	0.1	......	......	......	0.1	......	......	
95	0	5.40						
	0.1	8.22	......	.017	0.1	......	......	
96	0	5.25						
	0.1	8.37	......	.0185	0.1	......	......	
97	0	5.20						
	0.1	8.39	......	.0185	0.1	......	......	After standing through the dinner-hour.
98	0	5.20						
	0.1	8.30	......	.018	0.1	......	......	
99	0	5.10						
	0.1	8.13	......	.018	0.1	......	......	

* Not taken.

TABLE 36.—*Experiment to determine the resistance, &c., of a gun-wire drawn from Norway iron (HΦS) furnished by Messrs. Naylor & Co.*—Continued.

Number of application.	Torsion to the left.				Torsion to the right.			Remarks.
	Decimal part of one turn.	Strain required 1 foot from center.	Time in which torsion was produced.	Resilience.	Decimal part of one turn.	Time in which torsion was produced.	Resilience.*	
		Lbs.	*m. s.*	*Turns.*		*m. s.*	*Turns.*	
100	0	5.00						
	0.1	8.18	....	.018—	0.1	......	....	
101	0	5.00						
	0.1	8.13	....	.017	0.1	......	....	
102	0	4.95						
	0.1	8.25	....	.018	0.1	......	....	
103	0	4.90						
	0.1	8.05	....	.0185	0.1	......	....	
104	0	4.90						
	0.1	8.00	....	.0185	0.1	......	....	
105	0	4.85						
	0.1	7.87	....	.018	0.1	......	....	
106	0	4.83						
	0.1	8.00	....	.018—	0.1	......	....	
107	0	4.75						
	0.1	7.93	....	.018	0.1	......	....	
108	0	4.72						
	0.1	7.93	....	.018	0.1	......	....	
109	0	4.64						
	0.1	7.90	....	.0185	0.1	......	....	
110	0	4.58						
	0.1	7.84	....	.0185—	0.1	......	....	
111	0	4.50						
	0.1	7.82	....	.018—	0.1	......	....	
112	0	4.50						
	0.1	7.85	....	.019—	0.1	......	....	
113	0	4.56						
	0.1	7.80	....	.018	0.1	......	....	
114	0	4.45						
	0.1	7.80	....	.0185—	0.1	......	....	
115	0	4.47						
	0.1	7.65	....	.0185—	0.1	......	....	
116	0	4.40						
	0.1	7.65	....	.018	0.1	......	....	
117	0	4.43						
	0.1	7.72	....	.018	0.1	......	......	
118	0	(*)						
	0.1	7.70	....	.0185	0.1	......	....	
119	0	4.35						
	0.1	7.53	....	.018	0.1	......	....	
120	0	4.30						
	0.1	7.53	....	.018	0.1	......	....	
121	0	4.22						
	0.1	7.52	....	.0185	0.1	......	....	
122	0	4.20						
	0.1	7.50	....	.0185	0.1	......	....	
123	0	4.20						
	0.1	7.42	....	.019	0.1	......	....	
124	0	4.16						
	0.1	7.50	....	.019	0.1	......	....	
125	0	4.16						
	0.1	7.45	....	.019	0.1	......	....	
126	0	4.10						
	0.1	7.34	....	.019—	0.1	......	....	
127	0	4.32	....	....	......	......	....	**Resumed after standing from 4 p. m. of Saturday until 7 a. m. of Monday.**
	0.1	7.70	....	.092—	0.1	......	....	
128	0	4.25						
	0.1	7.63	....	.092	0.1	......	....	
129	0	4.12						
	0.1	7.47	....	.020—	0.1	......	....	
130	0	4.05						
	0.1	7.47	....	.092	0.1	......	....	
131	0	4.00						
	0.1	7.47	....	.092	0.1	......	....	
132	0	4.00						
	0.1	7.42	....	.092—	0.1	......	....	

* Not taken.

TABLE 36.—*Experiment to determine the resistance, &c., of a gun-wire drawn from Norway iron* (*HΦS*) *furnished by Messrs. Naylor & Co.*—Continued.

Number of application.	Torsion to the left.				Torsion to the right.			Remarks.
	Decimal part of one turn.	Strain required 1 foot from center.	Time in which torsion was produced.	Resilience.	Decimal part of one turn.	Time in which torsion was produced.	Resilience.*	
		Lbs.	*m. s.*	*Turns.*		*m. s.*	*Turns.*	
133	0	3.95						
	0.1	7.42	......	.092	0.1	......	....	
134	0	3.90						
	0.1	7.32	....	.0195	0.1	......	....	
135	0	3.90						
	0.1	7.10	....	.092—	0.1	......	....	
136	0	3.89						
	0.1	7.04	......	.0195	0.1	......	....	
137	0	3.89						
	0.1	7.00	....	.092	0.1	......	....	
138	0	3.90						
	0.1	7.03	....	.092	0.1	......	....	
139	0	(*)						
	0.1	7.00	....	.092	0.1	......	....	
140	0	(*)						
	0.1	7.10	......	.020	0.1	......	....	
141	0	3.70						
	0.1	6.93	....	.020	0.1	......	....	
142	0	(*)						
	0.1	6.80	......	.020—	0.1	......	....	
143	0	3.63						
	0.1	6.85	......	.020	0.1	......	....	
144	0	3.60						
	0.1	6.85	....	.0195	0.1	......	....	
145	0	3.58						
	0.1	6.75	......	.092—	0.1	......	....	
146	0	(*)						
	0.1	6.73	......	.092—	0.1	......	....	
147	0	(*)						
	0.1	6.75	....	.0195	0.1	......	....	
148	0	3.45						
	0.1	6.70	......	.0195	0.1	......	....	
149	0	3.45						
	0.1	6.50	....	.020—	0.1	......	....	
150	0	3.40						
	0.1	6.50	....	.020—	0.1	......	....	
151	0	3.35						
	0.1	6.50	....	.020	0.1	......	....	
152	0	3.35						
	0.1	6.50	....	.0195	0.1	......	....	
153	0	3.20						
	0.1	6.50	....	.0195	0.1	......	....	
154	0	3.25						
	0.1	6.45	....	.020	0.1	......	....	
155	0	3.27						
	0.1	6.45	....	.0195	0.1	......	....	
156	0	3.20						
	0.1	6.40	....	.0195	0.1	......	....	
157	0	3.25						
	0.1	6.35	....	.020	0.1	......	....	
158	0	3.17						
	0.1	6.34	......	.0195	0.1	......	....	
159	0	3.20						
	0.1	6.30	....	.020	0.1	......	....	
160	0	3.14						
	0.1	6.20	....	.020	0.1	......	....	
161	0	3.13						
	0.1	6.29	....	.020	0.1	......	....	
162	0	3.11						
	0.1	6.12	....	.020	0.1	......	....	
163	0	3.08						
	0.1	6.06	....	.020	0.1	......	....	
164	0	3.03						
	0.1	6.06	......	.020	0.1	......	....	
165	0	3.00						
	0.1	6.05	....	.020	0.1	......	....	

* Not taken.

TABLE 36.—*Experiment to determine the resistance, &c., of a gun-wire drawn from Norway iron (HΦS) furnished by Messrs. Naylor & Co.*—Continued.

Number of application.	Torsion to the left. Decimal part of one turn.	Torsion to the left. Strain required 1 foot from center.	Torsion to the left. Time in which torsion was produced.	Torsion to the left. Resilience.	Torsion to the right. Decimal part of one turn.	Torsion to the right. Time in which torsion was produced.	Torsion to the right. Resilience.*	Remarks.
		Lbs.	*m. s.**	*Turns.*		*m. s.*	*Turns.*	
166	0	2.92						
	0.1	6.00	....	.020	0.1	......	....	
167	0	2.95						
	0.1	5.97	....	.020	0.1	......	....	
168	0	2.95						
	0.1	5.97	....	.020	0.1	......	....	
169	0	2.94						
	0.1	5.95	....	.020	0.1	......	......	
170	0	2.94						
	0.1	5.93	....	.020	0.1	......	....	
171	0	2.90						
	0.1	5.92	....	.020	0.1	......	....	
172	0	2.87						
	0.1	5.90	....	.020—	0.1	.....	....	
173	0	2.90						
	0.1	5.90	....	.020—	0.1	......	....	
174	0	2.87						
	0.1	5.86	....	.020	0.1	......	... ...	
175	0	2.82						
	0.1	5.86	....	.020	0.1	......	....	
176	0	2.82						
	0.1	5.75	....	.020	0.1	......	....	
177	0	2.80						
	0.1	5.75	....	.020	0.1	......	....	
178	0	2.80						
	0.1	5.73	....	.020	0.1	......	....	
179	0	2.78						
	0.1	5.73	....	.020	0.1	......	....	
180	0	2.72						
	0.1	5.72	....	.020	0.1	......	....	
181	0	2.72						
	0.1	5.68	....	.020	0.1	......	....	
182	0	2.67						
	0.1	5.60	....	.0195	0.1	......	....	
183	0	2.68						
	0.1	5.60	....	.0195	0.1	......	....	
184	0	2.73	....	....	......	.....	....	After standing 1 hour.
	0.1	5.62	....	.092—	0.1	......	....	
165	0	2.63						
	0.1	5 50	....	.092—	0.1	......	....	
186	0	2.63						
	0.1	5.55	....	.092	0.1	......	....	
187	0	2.60						
	0.1	5.50	....	.092	0.1	......	....	
188	0	2.60						
	0.1	5.42	....	.092—	0.1	......	....	
189	0	2.58						
	0.1	5.45	.. ....	.092—	0.1	......	....	
190	0	2.58						
	0.1	5.43	... ..	.092	0.1	......	....	
191	0	2.56						
	0.1	5.52	....	.092—	0.1	......	....	
192	0	2.55						
	0.1	5.40	....	.092	0.1	......	....	
193	0	2.53						
	0.1	5.40	....	.020	0.1	......	....	
194	0	2.53						
	0.1	5.40	....	.020	0.1	......	......	
195	0	2.48						
	0.1	5.40	......	.092—	0.1	......	....	
196	0	2.47						
	0.1	5.40	......	.020	0.1	......	....	
197	0	2.45						
	0.1	5.33	......	.092	0.1	......	....	
198	0	2.40						
	0.1	5.30	....	.092	0.1	......	....	

* Not taken.

TABLE 36.—*Experiment to determine the resistance, &c., of a gun-wire drawn from Norway iron (HΦS) furnished by Messrs. Naylor & Co.*—Continued.

Number of application.	Torsion to the left.				Torsion to the right.			Remarks.
	Decimal part of one turn.	Strain required 1 foot from center.	Time in which torsion was produced.	Resilience.	Decimal part of one turn.	Time in which torsion was produced.	Resilience.*	
		Lbs.	*m. s.*	*Turns.*		*m. s.*	*Turns.*	
199	0	2.33						
	0.1	5.30	....	.092–	0.1	......	....	
200	0	2.35						
	0.1	5.27	....	.092	0.1	......	....	
201	0	2.39						
	0.1	5.27	....	.092–	0.1	......	....	
202	0	2.39						
	0.1	5.25	....	.092	0.1	......	....	
203	0	2.30						
	0.1	5.22	....	.092	0.1	......	....	
204	0	2.28						
	0.1	5.22	....	.092	0.1	......	....	
205	0	2.28						
	0.1	5.10	....	.092	0.1	......	....	
206	0	2.28						
	0.1	5.08	....	.092	0.1	......	....	
207	0	(*)						
	0.1	5.10	....	.092	0.1	......	......	
208	0	2.27						
	0.1	5.14	....	.092	0.1	......	....	
209	0	2.26						
	0.1	5.12	....	.092	0.1	......	....	
210	0	2.23						
	0.1	5.10	....	.092	0.1	......	......	
211	0	2.22						
	0.1	5.05	....	.092–	0.1	......	....	
212	0	2.21						
	0.1	5.05	....	.092–	0.1	......	....	
213	1	2.20						
	0.1	5.05	....	.092	0.1	....	....	
214	0	2.17						
	0.1	(*)	....	.092	0.1	......	......	
215	0	2.13						
	0.1	4.95	....	.092	0.1	......	....	
216	0	2.17	....	....	......	.....	....	After standing over night.
	0.1	5.10	....	.022	0.1	.....	......	
217	0	2.17						
	0.1	5.08	....	.0215	0.1	.....	....	
218	0	2.17						
	0.1	5.00	....	.021–	0.1	......	......	
219	0	2.15						
	0.1	5.00	....	.021–	0.1	......	....	
220	0	2.12						
	0.1	4.92	....	.021	0.1	......	....	
221	0	2.12						
	0.1	4.88	....	.0215	0.1	......	......	
222	0	(*)						
	0.1	4.88	....	.021	0.1	.....	......	
223	0	2.07						
	0.1	4.87	....	.021	0.1	......	......	
224	0	2.00						
	0.1	4.83	....	.021–	0.1	......	....	
225	0	2.00						
	0.1	4.80	....	.021	0.1	......	......	
226	0	2.00						
	0.1	4.77	....	.021	0.1	......	......	
227	0	1.97						
	0.1	4.73	....	.0205	0.1	.....	......	
228	0	1.97						
	0.1	4.73	....	.021	0.1	......	....	
229	0	1.97						
	0.1	4.73	....	.021–	0.1	......	......	
230	0	1.96						
	0.1	4.69	....	.021	0.1	.....	....	
231	0	1.95	....	....	......	.....	......	After standing about three hours.
	0.1	4.66	....	.021	0.1	......	....	

* Not taken.

TABLE 36.—*Experiment to determine the resistance, &c., of a gun-wire drawn from Norway iron (HΦS) furnished by Messrs. Naylor & Co.*—Continued.

Number of application.	Torsion to the left.				Torsion to the right.			Remarks.
	Decimal part of one turn.	Strain required 1 foot from center.	Time in which torsion was produced.	Resilience.	Decimal part of one turn.	Time in which torsion was produced.	Resilience.*	
		Lbs.	*m. s.*	*Turns.*		*m. s.*	*Turns.*	
232	0	1.91						
	0.1	4.66	....	.0215	0.1	......	....	
233	0	1.88						
	0.1	4.65	....	.021	0.1	......	....	
234	0	1.87						
	0.1	4.61	....	.021	0.1	......	....	
235	0	1.87						
	0.1	4.50	....	.021—	0.1	......	....	
236	0	1.87						
	0.1	4.49	....	.021—	0.1	......	....	
237	0	1.87						
	0.1	4.41	....	.0205-	0.1	......	....	
238	0	1.84						
	0.1	4.40	....	.0205	0.1	......	....	
239	0	1.84						
	0.1	4.20	....	.020	0.1	......	....	
240	0	1.84						
	0.1	4.19	....	.020	0.1	......	....	
241	0	1.82						
	0.1	4.20	....	.020	0.1	......	......	
242	0	1.81						
	0.1	4.34	....	.020	0.1	.....	....	
243	0	1.78						
	0.1	4.25	....	.020	0.1	.....	....	
244	0	1.77						
	0.1	4.25	....	.020	0.1	......	....	
245	0	1.76						
	0.1	4.25	....	.020	0.1	.....	....	
246	0	1.75						
	0.1	4.25	....	.021	0.1	......	....	
247	0	1.75						
	0.1	4.25	....	.020	0.1	.....	....	
248	0	1.72						
	0.1	4.25	....	.092—	0.1	......	....	
249	0	1.78	....	....	......	......	....	After standing over night.
	0.1	4.42	....	.092—	0.1	......	....	
250	0	1.75						
	0.1	4.33	....	.092	0.1	......	....	
251	0	1.73						
	0.1	4.33	....	.092	0.1	......	....	
252	0	1.70						
	0.1	4.27	....	.092	0.1	......	....	
253	0	1.68						
	0.1	4.25	....	.092	0.1	......	....	
254	0	1.65						
	0.1	4.20	......	.092	0.1	.....	....	
255	0	1.65						
	0.1	4.19	....	.092	0.1	......	....	
256	0	1.64						
	0.1	4.18	....	.092	0.1	......	....	
257	0	1.62						
	0.1	4.13	....	.092	0.1	.....	....	
258	0	1.62						
	0.1	4.13	....	.092—	0.1	......	....	
259	0	1.60						
	0.1	4.05	. ...	.092—	0.1	......	....	
260	0	1.60						
	0.1	4.00	....	.092—	0.1	......	....	
261	0	1.58						
	0.1	4.00	....	.092—	0.1	......	....	
262	0	1.58						
	0.1	4.00	....	.0205	0.1	......	....	
263	0	1.58						
	0.1	4.00	....	.020	0.1	......	....	
264	0	1.55						
	0.1	3.95	....	.092—	0.1	......	....	

* Not taken.

TABLE 36.—*Experiment to determine the resistance, &c., of a gun-wire drawn from Norway iron (HΦS) furnished by Messrs. Naylor & Co.*—Continued.

Number of application.	Torsion to the left.				Torsion to the right.			Remarks.
	Decimal part of one turn.	Strain required 1 foot from center.	Time in which torsion was produced.	Resilience.	Decimal part of one turn.	Time in which torsion was produced.	Resilience.*	
		Lbs.	*m. s.*	*Turns.*		*m. s.*	*Turns.*	
265	0	1. 52						
	0. 1	3. 95	....	. 092	0. 1	......	....	
266	0	1. 52						
	0. 1	3. 93	....	. 092—	0. 1	......	....	
267	0	1. 52						
	0. 1	3. 90	....	. 019	0. 1	......	....	
268	0	1. 52						
	0. 1	3. 90	....	. 019	0. 1	......	....	
269	0	1. 48						
	0. 1	3. 90	....	. 092	0. 1	......	....	
270	0	1. 48						
	0. 1	3. 85	....	. 0205	0. 1	......	....	
271	0	1. 48						
	0. 1	3. 83	....	. 0205	0. 1	......	....	
272	0	1. 48						
	0. 1	3. 73	....	. 021	0. 1	......	....	
273	0	1. 48						
	0. 1	3. 73	....	. 092—	0. 1	......	....	
274	0	1. 45						
	0. 1	3. 73	....	. 092—	0. 1	......	....	
275	0	1. 45						
	0. 1	3. 62	....	. 092—	0. 1	......	....	
276	0	1. 43						
	0. 1	3. 62	....	. 092—	0. 1	......	....	
277	0	1. 35						
	0. 1	3. 57	....	. 092	0. 1	......	....	
278	0	1. 35						
	0. 1	3. 53	....	. 092	0. 1	......	....	
279	0	1. 35						
	0. 1	3. 45	....	. 022	0. 1	......	....	
280	0	1. 38						
	0. 1	3. 40	....	. 092—	0. 1	......	....	
281	0	1. 38						
	0. 1	3. 40	....	. 022	0. 1	......	....	
282	0	1. 38						
	0. 1	3. 40	....	. 022	0. 1	......	....	
283	0	1. 35						
	0. 1	3. 40	....	. 021	0. 1	......	....	
284	0	1. 35						
	0. 1	3. 40	....	. 020	0. 1	......	....	
285	0	1. 35						
	0. 1	3. 35	....	. 020	0. 1	......	....	
286	0	1. 33						
	0. 1	3. 32	....	. 020	0. 1	......	....	
287	0	1. 40	....	....	......	......	....	After standing over one day and night.
	0. 1	3. 55	....	. 021	0. 1	......	....	
288	0	1. 38						
	0. 1	3. 44	....	. 0215	0. 1	......	....	
289	0	1. 37						
	0. 1	3. 43	....	. 0215	0. 1	......	....	
290	0	1. 35						
	0. 1	3. 42	....	. 022	0. 1	......	....	
291	0	1. 35						
	0. 1	3. 37	....	. 0215	0. 1	......	....	
292	0	1. 34						
	0. 1	3. 30	....	. 020	0. 1	......	....	
293	0	1. 32						
	0. 1	3. 30	....	. 021	0. 1	......	....	
294	0	1. 30						
	0. 1	3. 30	....	. 021	0. 1	......	....	
295	0	1. 27						
	0. 1	3. 28	....	. 019	0. 1	......	....	
296	0	1. 27						
	0. 1	3. 24	....	. 020	0. 1	......	....	
297	0	1. 27						
	0. 1	3. 24	....	. 021	0. 1	......	....	

* Not taken.

TABLE 36.—*Experiment to determine the resistance, &c., of a gun-wire drawn from Norway iron (HΦS) furnished by Messrs. Naylor & Co.*—Continued.

Number of application.	Torsion to the left.				Torsion to the right.			Remarks.
	Decimal part of one turn.	Strain required 1 foot from center.	Time in which torsion was produced.	Resilience.	Decimal part of one turn.	Time in which torsion was produced.	Resilience.*	
		Lbs.	*m. s.*	*Turns.*		*m. s.*	*Turns.*	
298	0	1.26						
	0.1	3.22	....	.0215	0.1	......	....	
299	0	1.25						
	0.1	3.19	....	.020—	0.1	......	....	
300	0	1.25						
	0.1	3.15	....	.021	0.1	......	....	
301	0	1.24						
	0.1	3.15	....	.0205	0.1	......	....	
302	0	1.23						
	0.1	3.13	....	.022—	0.1	......	....	
303	0	1.23						
	0.1	3.10	....	.021	0.1	......	....	
304	0	1.21						
	0.1	3.10	....	.021	0.1	......	....	
305	0	1.20						
	0.1	3.00	....	.020—	0.1	......	....	
306	0	1.15						
	0.1	3.00	....	.020—	0.1	......	....	
307	0	1.17						
	0.1	2.97	....	.019	0.1	......	....	
308	0	1.18						
	0.1	2.97	....	.020	0.1	......	....	
309	0	1.17						
	0.1	2.93	....	.020—	0.1	......	....	
310	0	1.15						
	0.1	2.93	....	.020	0.1	......	....	
311	0	1.11						
	0.1	2.81	....	.021	0.1	......	....	
312	0	1.09						
	0.1	2.82	....	.0215	0.1	......	....	
313	0	1.08						
	0.1	2.81	....	.031	0.1	......	....	
314	0	1.06						
	0.1	2.78	....	.022	0.1	......	....	
315	0	1.05						
	0.1	2.76	....	.022	0.1	......	....	
316	0	1.06						
	0.1	2.75	....	.022	0.1	......	....	
317	0	1.06						
	0.1	2.73	....	.021	0.1	......	....	
318	0	1.06						
	0.1	2.70	....	.022—	0.1	......	....	
319	0	1.06						
	0.1	2.69	....	.022	0.1	......	....	
320	0	1.05						
	0.1	2.67	....	.022	0.1	......	....	
321	0	1.05						
	0.1	2.66	....	.0225	0.1	......	....	
322	0	1.04						
	0.1	2.65	....	.0205	0.1	......	....	
323	0	1.03						
	0.1	2.63	....	.021	0.1	......	....	
324	0	1.03						
	0.1	2.61	....	.021	0.1	......	....	
325	0	1.02						
	0.1	2.61	....	.020	0.1	......	....	
326	0	1.02						
	0.1	2.59	....	.020—	0.1	......	....	
327	0	1.00						
	0.1	2.59	....	.020	0.1	......	....	
328	0	1.00						
	0.1	2.60	....	.020	0.1	.....	....	
329	0	0.99						
	0.1	2.59	....	.020	0.1	......	......	
330	0	0.98						
	0.1	2.54	....	.020	0.1	......	....	

* Not taken.

Table 36.—*Experiment to determine the resistance, &c., of a gun-wire drawn from Norway iron (HΦS) furnished by Messrs. Naylor & Co.*—Continued.

Number of application.	Torsion to the left.				Torsion to the right.			Remarks.
	Decimal part of one turn.	Strain required 1 foot from center.	Time in which torsion was produced.	Resilience.	Decimal part of one turn.	Time in which torsion was produced.	Resilience.*	
		Lbs.	*m. s.*	*Turns.*		*m. s.*	*Turns.*	
331	0	0.99						
	0.1	2.54	....	.021	0.1	......	....	
332	0	0.98						
	0.1	2.53	....	.021	0.1	......	....	
333	0	0.97						
	0.1	2.49	....	.020	0.1	......	....	
334	0	0.96						
	0.1	2.50	....	.020	0.1	......	....	
335	0	0.95						
	0.1	2.50	....	.020	0.1	......	....	
336	0	0.95						
	0.1	2.48	....	.021	0.1	......	....	
337	0	0.93						
	0.1	2.45	....	.019	0.1	......	....	
338	0	0.93						
	0.1	2.45	....	.021	0.1	......	....	
339	0	0.93						
	0.1	2.43	....	.020	0.1	......	....	
340	0	0.93						
	0.1	2.45	....	.019	0.1	......	....	
341	0	0.92						
	0.1	2.45	....	.020—	0.1	......	....	
342	0	0.92						
	0.1	2.45	....	.017—	0.1	......	....	
343	0	0.93						
	0.1	2.43	....	.020—	0.1	......	....	
344	0	0.90						
	0.1	2.40	....	.021	0.1	......	....	
345	0	0.89						
	0.1	2.38	....	.021	0.1	......	....	
346	0	0.90						
	0.1	2.36	....	.020	0.1	......	....	
347	0	0.87						
	0.1	2.35	....	.019	0.1	......	....	
348	0	0.87						
	0.1	2.33	....	.019	0.1	......	....	
349	0	0.87						
	0.1	2.33	....	.021	0.1	......	....	
350	0	0.87						
	0.1	2.33	....	.019	0.1	......	....	
351	0	0.86						
	0.1	2.30	....	.021	0.1	......	....	
352	0	0.86						
	0.1	2.28	....	.019	0.1	......	....	
353	0	0.85						
	0.1	2.25	....	.020—	0.1	......	....	
354	0	0.85						
	0.1	2.25	....	.020—	0.1	......	....	
355	0	0.83						
	0.1	2.25	....	.0205	0.1	......	....	
356	0	0.83						
	0.1	2.23	....	.020—	0.1	......	....	
357	0	0.83						
	0.1	2.20	....	.022	0.1	......	....	
358	0	0.83						
	0.1	2.22	....	.022	0.1	......	....	
359	0	0.82						
	0.1	2.20	....	.020	0.1	......	....	
360	0	0.80						
	0.1	2.20	....	.020	0.1	......	....	
361	0	0.78						
	0.1	2.15	....	.021	0.1	......	....	
362	0	0.77						
	0.1	2.14	....	.020	0.1	......	....	
363	0	0.75						
	0.1	2.12	....	.019	0.1	......	....	

* Not taken.

TABLE 36.—*Experiment to determine the resistance, &c., of a gun-wire drawn from Norway iron (HΦS) furnished by Messrs. Naylor & Co.*—Continued.

Number of application.	Torsion to the left.				Torsion to the right.			Remarks.
	Decimal part of one turn.	Strain required 1 foot from center.	Time in which torsion was produced.	Resilience.	Decimal part of one turn.	Time in which torsion was produced.	Resilience.*	
		Lbs.	*m. s.*	*Turns.*		*m. s.*	*Turns.*	
364	0	0.75						
	0.1	2.11	....	.020—	0.1	......	....	
365	0	0.74						
	0.1	2.07	....	.021	0.1	......	....	
366	0	0.7						
	0.1	(*)	....	(*)	0.1	......	....	
367	0	0.69						
	0.1	1.68	....	.015	0.1	......	....	
368	0	0.68						
	0.1	1.66	....	.016	0.1	......	....	
369	0	0.68						
	0.1	1.67	....	.016	0.1	......	....	
370	0	0.67						
	0.1	1.64	....	.016	0.1	......	....	
371	0	0.66						
	0.1	1.64	....	.020	0.1	......	....	
372	0	5.65						
	0.1	1.62	....	.0165	0.1	......	....	
373	0	0.64						
	0.1	1.62	....	.017—	0.1	......	....	Two small pieces became detached.
374	0	0.63						
	0.1	1.62	....	.016	0.1	......	....	

* Not taken.

TABLE 37.—*Experiment to determine the resistance, elasticity, and endurance under reversed torsions of a gun-wire drawn from Martin steel manufactured by the New Jersey Steel and Iron Company.*

[Mark, C K· ; size, 0″.299 x 0″.2988.—Experiment No. 1268.]

Number of application.	Torsion to the left.				Torsion to the right.			Remarks.
	Decimal part of one turn.	Strain required 1 foot from center.	Time in which torsion was produced.	Resilience.	Decimal part of one turn.	Time in which torsion was produced.	Resilience.	
		Lbs.	*m. s.*	*Turns.*		*m. s.*	*Turns.*	
1	0.1	30.05	2 40	.012	0.1	0 30	.012—	Specimen annealed at a heat between the melting-points of bronze and copper.
2	0	30.00						
	0.1	36.50	3 00	.013	0.1	0 30	.012—	
3	0	30.87						Length, 1 inch.
	0.1	37.20	8 00	.0125	0.1	0 30	.012—	
4	0	31.13						Each return to the extreme of left-hand torsion was made with sufficient allowance of time to obtain very nearly the whole extent of torsion that would result from the continuance of the strain given.
	0.1	37.42	7 30	.014—	0.1	0 30	.0125—	
5	0	31.20						
	0.1	37.42	6 30	.014—	0.1	0 30	.013—	
6	0	31.35						
	0.1	37.55	6 20	.014	0.1	0 30	.013—	
7	0	31.10						
	0.1	37.50	10 00	.014	0.1	0 30	.013—	
8	0	31.23						
	0.1	37.60	7 40	.0135	0.1	0 30	.013—	
9	0	31.45						
	0.1	37.90	12 40	.015	0.1	0 30	.013—	
10	0	31.37						
	0.1	37.85	14 00	.015	0.1	0 30	.013—	
11	0	31.35						
	0.1	37.82	9 10	.015	0.1	0 30	.013—	
12	0	31.30						
	0.1	37.82	9 00	.0145	0.1	0 30	.013—	
13	0	31.25						
	0.1	37.77	8 00	.0145	0.1	0 30	.013—	
14	0	31.10						
	0.1	37.70	10 30	.015—	0.1	0 30	.013—	
15	0	31.37						
	0.1	38.10	4 30	.015	0.1	0 30	.013—	After intermission of two days.
16	0	31.25						
	0.1	38.00	5 00	.015	0.1	0 30	.013—	
17	0	31.10						
	0.1	37.93	6 00	.0155	0.1	0 30	.013—	
18	0	31.00						
	0.1	37.87	7 00	.015—	0.1	0 30	.013—	
19	0	30.80						
	0.1	37.60	6 30	.015	0.1	0 30	.0135	
20	0	30.51						
	0.1	37.35	6 40	.015	0.1	0 30	.0135	
21	0	30.10						
	0.1	36.80	3 00	.015—	0.1	0 30	.0135	
22	0	29.60						
	0.1	36.15	4 30	.015	0.1	0 30	.013—	
23	0	28.60						
	0.1	35.20	3 00	.015	0.1	0 30	.0135	
24	0	27.35						
	0.1	33.75	3 15	.015	0.1	0 30	.0135	
25	0	26.15						
	0.1	32.60	6 30	.015	0.1	0 30	.0135	
26	0	24.85						
	0.1	31.55	6 45	.016	0.1	0 30	.0135	
27	0	23.98						
	0.1	30.70	6 30	.016	0.1	0 30	.0135	
28	0	23.10						
	0.1	29.85	8 00	.016	0.1	0 30	.0135	
29	0	22.40						
	0.1	29.12	6 00	.0165	0.1	0 30	.014—	
30	0	21.80						Seams appeared on two sides; cross-lines separated about 0″.03.
	0.1	28.50	4 30	.0165	0.1	0 30	.0135	
31	0	21.20						
	0.1	27.90	4 30	.0165	0.1	0 30	.0135	
32	0	20.60						
	0.1	27.35	7 30	.0165	0.1	0 30	.0135	

TABLE 37.—*Experiment to determine the resistance, &c., of a gun-wire drawn from Martin steel manufactured by the New Jersey Steel and Iron Company*—Continued.

Number of application.	Torsion to the left.				Torsion to the right.			Remarks.
	Decimal part of one turn.	Strain required 1 foot from center.	Time in which torsion was produced.	Resilience.	Decimal part of one turn.	Time in which torsion was produced.	Resilience.	
		Lbs.	*m. s.*	*Turns.*		*m. s.*	*Turns.*	
33	0	19.90						
	0.1	26.80	6 00	.0165	0.1	0 30	.0135	
34	0	19.40	....	....	......	......	....	Seam on each of three sides.
	0.1	26.35	6 45	.017—	0.1	0 30	.014--	
35	0	18.85						
	0.1	25.75	6 00	.017—	0.1	0 30	.0145	
36	0	....	....	....	......	......	....	Taken out of machine.

TABLE 38.—*Experiment to determine the resistance, elasticity, and endurance und.r reversed torsions of a gun-wire drawn from Martin steel manufactured by the New Jersey Steel and Iron Company.*

[Mark, O; size, 0''.3014 x 0''.3012.—Experiment No. 1269.]

Number of application.	Torsion to the left.				Torsion to the right.			Remarks.
	Decimal part of one turn.	Strain required 1 foot from center.	Time in which torsion was produced.	Resilience.	Decimal part of one turn.	Time in which torsion was produced.	Resilience.	
		Lbs.	*m. s.*	*Turns.*		*m. s.*	*Turns.*	
1	0.1	21.10	2 40	.0075	0.1	0 30	.0075	Specimen annealed at a heat between the melting-points of bronze and copper.
2	0	25.50						
	0.1	28.45	4 00	.010	0.1	0 30	.008—	
3	0	27.00						
	0.1	29.40	3 40	.011	0.1	0 30	.008—	Length, 1 inch.
4	0	27.70						
	0.1	29.90	8 00	.011	0.1	0 30	.0015	Each return to the extreme of left-hand torsion was made with sufficient allowance of time to obtain very nearly the whole extent of torsion that would result from the continuance of the strain given.
5	0	27.70						
	0.1	30.12	5 30	.011	0.1	0 30	.0015	
6	0	27.75						
	0.1	30.25	10 00	.011	0.1	0 30	.0015	
7	0	27.83						
	0.1	30.35	13 00	.0115	0.1	0 30	.091—	
8	0	27.80						
	0.1	30.45	10 30	.011	0.1	0 30	.091—	
9	0	27.80						
	0.1	30.45	7 30	.011	0.1	0 30	.091—	
10	0	27.80						
	0.1	30.53	7 30	.011	0.1	0 30	.091—	
11	0	27.80						
	0.1	30.55	7 45	.011	0.1	0 30	.091—	
12	0	27.80						
	0.1	30.55	5 30	.011	0.1	0 30	.091—	
13	0	27.80						
	0.1	30.55	7 30	.011	0.1	0 30	.091—	
14	0	27.65						
	0.1	30.52	8 40	.0115	0.1	0 30	.091—	
15	0	27.65						
	0.1	30.55	8 00	.012	0.1	0 30	.090—	
16	0	29.50						After intermission from Saturday evening to Monday morning.
	0.1	32.35	9 30	.012	0.1	0 30	.090—	
17	0	28.60						
	0.1	31.75	8 30	.012	0.1	0 30	.090—	
18	0	28.23						
	0.1	31.47	10 00	.012	0.1	0 30	.090—	
19	0	28.15						
	0.1	31.25	12 00	.012	0.1	0 30	.090—	
20	0	27.90						
	0.1	31.20	8 30	.012	0.1	0 30	.090—	
21	0	27.86						
	0.1	31.00	8 35	.012	0.1	0 30	.090—	
22	0	27.83						
	0.1	30.97	12 30	.012	0.1	0 30	.090—	
23	0	27.70						
	0.1	30.92	7 00	.012	0.1	0 30	.090—	
24	0	27.62						
	0.1	30.83	11 00	.012	0.1	0 30	.010	
25	0	29.00						After intermission of about 60 hours.
	0.1	32.00	6 45	.012	0.1	0 30	.010	
26	0	28.40						
	0.1	31.55	10 00	.012	0.1	0 30	.010	
27	0	27.85						
	0.1	31.30	9 00	.012	0.1	0 30	.010	
28	0	27.75						
	0.1	31.15	10 00	.012	0.1	0 30	.010	
29	0	27.65						
	0.1	30.95	7 00	.012	0.1	0 30	.010	
30	0	27.45						
	0.1	30.90	10 00	.012	0.1	0 30	.010	
31	0	27.35						
	0.1	30.80	6 00	.012	0.1	0 30	.010	
32	0	27.10						
	0.1	30.55	6 00	.012	0.1	0 30	.010	
33	0	26.98						
	0.1	30.45	10 15	.012	0.1	0 30	.010	

TABLE 33.—*Experiment to determine the resistance, &c., of a gun-wire drawn from Martin steel manufactured by the New Jersey Steel and Iron Company*—Continued.

Number of application.	Torsion to the left.				Torsion to the right.			Remarks.
	Decimal part of one turn.	Strain required 1 foot from center.	Time in which torsion was produced.	Resilience.	Decimal part of one turn.	Time in which torsion was produced.	Resilience.	
		Lbs.	*m. s.*	*Turns.*		*m. s.*	*Turns.*	
34	0	26.75						
	0.1	30.35	5 00	.012	0.1	0 30	.010	
35	0	26.60						
	0.1	30.20	7 00	.012	0.1	0 30	.010	
36	0	26.40						
	0.1	30.00	6 00	.012	0.1	0 30	.010	
37	0	26.17						
	0.1	29.75	8 30	.012	0.1	0 30	.010	
38	0	25.90						
	0.1	29.60	10 00	.012	0.1	0 30	.010	
39	0	25.65						
	0.1	29.35	6 30	.012	0.1	0 30	.010	
40	0	25.45						
	0.1	29.05	7 00	.012	0.1	0 30	.010	
41	0	25.10						
	0.1	28.90	7 00	.012	0.1	0 30	.010	
42	0	24.75						
	0.1	28.55	7 20	.012	0.1	0 30	.010	
43	0	24.45						
	0.1	28.50	9 30	.012	0.1	0 30	.010	
44	0	24.10						
	0.1	28.07	7 00	.012	0.1	0 30	.010	
45	0	23.75	....	....	......	......	....	Split begins to show.
	0.1	27.85	7 30	.012	0.1	0 30	.010	
46	0	23.48						
	0.1	27.53	8 30	.012	0.1	0 30	.010	
47	0	23.00						
	0.1	27.10	6 45	.012	0.1	0 30	.010	
48	0	22.58						
	0.1	26.95	8 00	.012	0.1	0 30	.010	
49	0	22.52	....	....	......	......	....	Seam on two sides.
	0.1	26.93	6 45	.013	0.1	0 30	.010	
50	0	22.05						
	0.1	26.50	7 30	.013	0.1	0 30	.010	
55	0	(*)	....	....	......	......	....	Seam on each side.
	0.1	24.50	5 00	.013	0.1	0 30	.011	
60	0	17.40						
	0.1	22.90	7 30	.0135	0.1	0 30	.0115	
65	0	15.50						
	0.1	21.00	7 00	.0135	0.1	0 30	.0115	
70	0	13.85						
	0.1	19.37	6 45	.014	0.1	0 30	.012	
75	0	12.45						
	0.1	17.87	7 30	.015	0.1	0 30	.012	
80	0	11.12	....	....	......	......	....	On 82d twist cracked, and opened considerably.
	0.1	16.80	4 40	.015	0.1	0 30	.011	
85	0	6.70						
	0.298	13.31	....	....	......	......	....	Torsion continued to breaking.
		18.81	....	(Broke.)				

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* Not taken.

TABLE 39.—*Experiment to determine the resistance, elasticity, and endurance under reversed torsions of a gun-wire drawn from "open-hearth" steel. Manufacturer's name withheld by request.*

[Mark, B S co. ; size, 0''.2965 x 0''.2971.—Experiment No. 1270.]

Number of application.	Torsion to the left. Decimal part of one turn.	Torsion to the left. Strain required 1 foot from center.	Torsion to the left. Time in which torsion was produced.	Torsion to the left. Resilience.	Torsion to the right. Decimal part of one turn.	Torsion to the right. Time in which torsion was produced.	Torsion to the right. Resilience.	Remarks.
		Lbs.	*m. s.*	*Turns.*		*m. s.*	*Turns.*	
1	0.1	18.25	7 10	.007	0.1	0 30	.0175	Specimen annealed at a heat between the melting-points of bronze and copper. Length, 1 inch. Each return to the extreme of left-hand torsion was made with sufficient allowance of time to obtain very nearly the whole extent of torsion that would result from the continuance of the strain given.
2	0	21.45						
	0.1	24.60	6 30	.007	0.1	0 30	.008—	
3	0	22.50						
	0.1	22.25	4 30	.010	0.1	0 30	.0085—	
4	0	22.75						
	0.1	25.60	5 00	.010	0.1	0 30	.008—	
5	0	23.00						
	0.1	25.74	5 13	.011	0.1	0 30	.008—	
6	0	22.90						After intermission of about 15 hours.
	0.1	25.70	7 00	.011	0.1	0 30	.0085	
7	0	22.75						
	0.1	25.60	7 30	.011—	0.1	3 30	.0085	
8	0	22.63						
	0.1	25.50	10 00	.011—	0.1	0 30	.0085	
9	0	22.57						A slight seam visible on one side.
	0.1	25.50	10 00	.0105	0.1	0 30	.0085	
10	0	22.53						
	0.1	25.40	8 00	.0105	0.1	0 30	.009—	
11	0	22.43						
	0.1	25.37	7 40	.0105	0.1	0 30	.009—	
12	0	22.37						
	0.1	25.30	7 45	.0105	0.1	0 30	.009—	
13	0	22.27						
	0.1	25.23	6 00	.011—	0.1	0 30	.009—	
14	0	22.10						
	0.1	25.15	6 20	.011	0.1	0 30	.009—	
15	0	21.90						
	0.1	24.98	7 15	.011	0.1	0 30	.009—	
16	0	21.80						
	0.1	24.90	8 20	.011	0.1	0 30	.009—	
17	0	21.65						
	0.1	24.75	8 40	.011	0.1	0 30	.009—	
18	0	21.45						
	0.1	24.50	9 00	.011	0.1	0 30	.009—	
19	0	21.35						
	0.1	24.47	7 00	.011	0.1	0 30	.009	
20	0	21.23						
	0.1	24.45	7 00	.011	0.1	0 30	.009	
21	0	21.25						After standing over night.
	0.1	24.43	6 30	.011	0.1	0 30	.009	
22	0	21.00						
	0.1	24.25	7 40	.0115	0.1	0 30	.009	
23	0	20.78						
	0.1	24.00	10 00	.0115	0.1	0 30	.009	
24	0	20.70						
	0.1	23.90	9 00	.011	0.1	0 30	.009	
25	0	20.50						
	0.1	23.80	9 45	.011	0.1	0 30	.009	
26	0	20.40						
	0.1	23.65	7 00	.011	0.1	0 30	.009	
27	0	20.20						
	0.1	23.55	7 30	.011	0.1	0 30	.009	
28	0	20.05						
	0.1	23.30	7 45	.011	0.1	0 30	.009	
29	0	19.87						
	0.1	23.20	7 00	.011	0.1	0.30	.009	
30	0	19.70						
	0.1	23.07	8 20	.011	0.1	0 30	.009	
31	0	19.55						
	0.1	22.95	7 00	.011	0.1	0 30	.009	
32	0	19.43						
	0.1	22.83	8 00	.011	0.1	0 30	.009	

TABLE 39.—*Experiment to determine the resistance, &c., of a gun-wire drawn from "open-hearth" steel*—Continued.

Number of application.	Torsion to the left.				Torsion to the right.			Remarks.
	Decimal part of one turn.	Strain required 1 foot from center.	Time in which torsion was produced.	Resilience.	Decimal part of one turn.	Time in which torsion was produced.	Resilience.	
		Lbs.	*m. s.*	*Turns.*		*m. s.*	*Turns.*	
33	0	19.32						
	0.1	22.70	9 00	.011	0.1	0 30	.009	
34	0	19.20						
	0.1	22.50	5 00	.011	0.1	0 30	.009	
35	0	19.10						The seam separates cross-lines about 0''.03.
	0.1	22.50	6 00	.011	0.1	0 30	.009	
40	0	18.70						
	0.1	22.00	9 00	.011	0.1	0 30	.009—	
45	0	18.15						
	0.1	21.47	5 30	.011	0.1	0 30	.0095	
50	0	17.49						
	0.1	21.00	10 00	.0115	0.1	0 30	.0095	
55	0	16.85						
	0.1	20.44	6 00	.011	0.1	0 30	.0095	The 59th turn was carried 0.01 too far.
60	0	16.25						
	0.1	19.30	6 00	.0115	0.1	0 30	.0095	
65	0	15.43						
	0.1	18.97	6 30	.1115—	0.1	0 30	.010—	
70	0	14.75						
	0.1	18.35	6 30	.1115	0.1	0 30	.010—	
75	0	14.00						
	0.1	17.70	5 00	.0115	0.1	0 30	.010—	
80	0	13.25						Began to crack transversely at middle and one end.
	0.1	16.95	6 00	.0115	0.1	0 30	.010	
85	0	12.50						
	0.1	16.25	7 00	.012	0.1	0 30	.010	
90	0	11.58						
	0.1	15.60	5 00	.012	0.1	0 30	.010	
95	0	(*)						
	0.1	14.97	4 30	.0125	0.1	0 30	.0015	
100	0	10.20						
	0.1	14.50	6 00	.0125	0	......	....	Set at 0 and taken out of machine.

* Not taken.

TABLE 40.—*Experiment to determine the resistance, elasticity, and endurance under reversed torsions of a gun-wire drawn from crucible cast steel manufactured by Hussey, Welles & Co.*

[Mark, H W co 4; size, 0''.300 x 0''.390.—Experiment No. 1272.]

Number of application.	Torsion to the left.				Torsion to the right.			Remarks.
	Decimal part of one turn.	Strain required 1 foot from center.	Time in which torsion was produced.	Resilience.	Decimal part of one turn.	Time in which torsion was produced.	Resilience.	
		Lbs.	*m. s.*	*Turns.*		*m. s.*	*Turns.*	
1	0.1	30.55	6 30	.012	0.1	0 30	.0115	Specimen annealed at a heat between the melting-points of bronze and copper. Length, 1 inch. Each return to the extreme of left-hand torsion was made with sufficient allowance of time to obtain very nearly the whole extent of torsion that would result from the continuance of the strain given.
2	0	28.00						
	0.1	34.40	5 00	.012	0.1	0 30	.0115	
3	0	28.35						
	0.1	34.85	6 30	.012	0.1	0 30	.0115	
4	0	28.35						
	0.1	34.80	6 15	.0125	0.1	0 30	.0115	
5	0	28.05						
	0.1	34.80	9 00	.013	0.1	0 30	.0115	
6	0	28.05						
	0.1	34.85	9 30	.013	0.1	0 30	.0115	
7	0	28.15						
	0.1	34.85	7 45	.013	0.1	0 30	.0115	
8	0	28.10						
	0.1	34.85	7 30	.013	0.1	0 30	.0115	
9	0	(*)						
	0.1	35.15	2 30	.013	0.1	0 30	.0115	
10	0	28.12						
	0.1	35.15	9 20	.013	0.1	0 30	.0115	
11	0	28.18						
	0.1	35.10	6 10	.0135	0.1	0 30	.0115	
12	0	28.08						
	0.1	35.05	6 00	.0135	0.1	0 30	.0115	
13	0	28.00						
	0.1	35.00	6 00	.0135	0.1	0 30	.0115	
14	0	27.98						
	0.1	34.90	6 30	.0135	0.1	0 30	.0115	
15	0	27.97						
	0.1	34.90	8 00	.0135	0.1	0 30	.0115	
16	0	27.94						
	0.1	34.85	8 30	.0135	0.1	0 30	.012—	
17	0	27.85						
	0.1	34.85	8 00	.0135	0.1	0 30	.0115	
18	0	27.85						
	0.1	34.83	9 30	.0135	0.1	0 30	.0115	
19	0	27.75						
	0.1	34.62	7 45	.0135	0.1	0 30	.0115	
20	0	27.72						
	0.1	34.65	8 00	.0135	0.1	0 30	.0115	After intermission of dinner-hour.
21	0	27.65						
	0.1	34.55	8 50	.0135	0.1	0 30	.0115	
22.	0	27.50						
	0.1	34.45	7 40	.0135	0.1	0 30	.0115	
23	0	27.40						
	0.1	34.54	6 30	.0135	0.1	0 30	.0115	
24	0	27.30						
	0.1	34.40	5 00	.0135	0.1	0 30	.0115	
25	0	27.00						
	0.1	34.20	7 00	.0135	0.1	0 30	.0115	
26	0	26.80						
	0.1	33.90	8 00	.0135	0.1	0 30	.0115	
27	0	26.50						
	0.1	33.43	6 10	.0135	0.1	0 30	.0115	
28	0	26.30						
	0.1	33.10	5 00	.0135	0.1	0 30	.0115	
29	0	25.75						
	0.1	32.73	6 30	.0135	0.1	0 30	.0115	
30	0	25.45						
	0.1	32.40	7 45	.0135	0.1	0 30	.0115	A seam discovered on the under side.
31	0	25.00						
	0.1	32.00	4 00	.0135	0.1	0 30	.0115	
32	0	24.70						
	0.1	31.51	7 30	.0135	0.1	0 30	.0115	
33	0	24.30						
	0.1	31.10	6 10	.0135	0.1	0 30	.012—	

* Not taken.

TABLE 40.—*Experiment to determine the resistance, &c., of a gun-wire drawn from crucible cast steel manufactured by Hussey, Welles & Co.*—Continued.

Number of application.	Torsion to the left.				Torsion to the right.			Remarks.
	Decimal part of one turn.	Strain required 1 foot from center.	Time in which torsion was produced.	Resilience.	Decimal part of one turn.	Time in which torsion was produced.	Resilience.	
		Lbs.	*m. s.*	*Turns.*		*m. s.*	*Turns.*	
34	0	23.80						
	0.1	30.65	5 00	.013	0.1	0 30	.012—	
35	0	23.35						
	0.1	30.00	6 00	.013	0.1	0 30	.012—	
36	0	22.70						
	0.1	29.55	6 15	.013	0.1	0 30	.012—	
37	0	22.26						A crack on the upper side.
	0.1	28.85	5 30	.0135	0.1	0 30	.012—	
38	0	21.65						
	0.1	28.44	9 00	.0135	0.1	0 30	.012—	
39	0	21.08						
	0.1	27.90	7 20	.0135	0.1	0 30	.012—	
40	0	20.55						
	0.1	27.18	5 15	.0135	0.1	0 30	.012—	
41	0	20.00						
	0.1	26.68	6 00	.0135	0.1	0 30	.012—	
42	0	19.35						
	0.1	26.08	7 20	.014+	0.1	0 30	.012—	
43	0	18.80						
	0.1	25.47	8 30	.014—	0.1	0 30	.012—	
44	0	18.20						Cracked on all sides.
	0.1	25.02	5 30	.014—	0.1	0 30	.012—	
45	0	17.75						After intermission of dinner-hour.
	0.1	24.55	8 25	.015	0.1	0 30	.0125	
46	0	17.20						
	0.1	24.00	5 30	.015	0.1	0 30	.013—	
47	0	16.75						
	0.1	23.50	7 00	.014	0.1	0 30	.013—	
48	0	16.40						
	0.1	23.05	5 00	.014	0.1	0 30	.013—	
49	0	15.90						
	0.1	22.65	5 00	.015	0.1	0 30	.013—	
50	0	15.63						
	0.1	22.35	5 00	.016	0.1	0 30	.013—	
51	0	15.10						
	0.1	21.83	5 00	.0155	0.1	0 30	.0135	
52	0	14.75						
	0.1	21.61	6 00	.016	0.1	0 30	.0135	
53	0	14.35						
	0.1	21.00	5 00	.016	0.1	0 30	.0135	
54	0	13.98						
	0.1	20.95	8 00	.016	0.1	0 30	.014	
55	0	13.60						
	0.1	20.70	8 00	.016	0.1	0 30	.014	
56	0	13.20						
	0.1	20.05	6 00	.016	0.1	0 30	.014	
57	0	12.92						After intermission of one night.
	0.1	19.86	5 15	.016	0.1	0 30	.0145	
58	0	12.60						
	0.1	19.45	7 10	.0165	0.1	0 30	.014—	
59	0	12.23						
	0.1	19.00	4 15	.017—	0.1	0 30	.014—	
60	0	11.78						
	0.1	18.68	8 20	.017	0.1	0 30	.014—	
61	0	11.42						
	0.1	18.45	9 00	.017	0.1	0 30	.015—	
62	0	11.10						
	0.1	18.00	6 00	.017	0.1	0 30	.015	
63	0	10.75						
	0.1	17.90	7 20	.0165	0.1	0 30	.0145	
64	0	10.40						
	0.1	17.65	8 00	.0165	0.1	0 30	.0145	
65	0	10.00						
	0.1	17.35	6 00	.0175	0.1	0 30	.015—	
66	0	9.73						
	0.1	17.23	9 00	.0175	0.1	0 30	.015—	

TABLE 40.—*Experiment to determine the resistance, &c., of a gun-wire drawn from crucible cast steel manufactured by Hussey, Welles & Co.*—Continued.

Number of application.	Torsion to the left.				Torsion to the right.			Remarks.
	Decimal part of one turn.	Strain required 1 foot from center.	Time in which torsion was produced.	Resilience.	Decimal part of one turn.	Time in which torsion was produced.	Resilience.	
		Lbs.	*m. s.*	*Turns.*		*m. s.*	*Turns.*	
67	0	9.25						
	0.1	16.95	6 30	.0175	0.1	0 30	.015—	
68	0	9.85						
	0.1	16.47	9 20	.0175	0.1	0 30	.015—	
69	0	(*)						
	0.1	15.25	4 30	.0175	0.1	0 30	.015	
70	0.320	19.00	....	(Failed)	......	......	....	Torsion continued to 0.526, when the specimen broke.
	0.526	(Broke.)						

* Not taken.

TABLE 41.—*Experiment to determine the resistance, elasticity, and endurance, under reversed torsions, of a gun-wire drawn from "Hobson's choice" steel (brand,* CHOICE (XX) EXTRA,) *made by Francis Hobson & Son, and procured from ordnance shops, Washington navy-yard.*

[Mark, H co 1; size, 0".3002 x 0".2952.—Experiment No. 1273.]

Number of application.	Torsion to the left.				Torsion to the right.			Remarks.
	Decimal part of one turn.	Strain required 1 foot from center.	Time in which torsion was produced.	Resilience.	Decimal part of one turn.	Time in which torsion was produced.	Resilience.	
		Lbs.	*m. s.*	*Turns.*		*m. s.*	*Turns.*	
1	0.1	34.15	8 40	.015	0.1	0 30	.0145	Specimen annealed at a heat between the melting-points of bronze and copper.
2	0	29.80						
	0.1	38.40	8 00	.015	0.1	0 30	.0145	
3	0	29.70						Length, 1 inch.
	0.1	38.50	7 25	.016	0.1	0 30	.0155	
4	0	29.70						Each return to the extreme of left-hand torsion was made with sufficient allowance of time to obtain very nearly the whole extent of torsion that would result from the continuance of the strain given.
	0.1	38.25	7 15	.016–	0.1	0 30	.0155	
5	0	29.37						
	0.1	37.65	6 05	.016–	0.1	0 30	.015	
6	0	28.70						
	0.1	36.80	4 30	.0155	0.1	0 30	.0145	A seam discovered on one side.
7	0	27.80						
	0.1	35.73	8 00	.0155	0.1	0 30	.014–	
8	0	26.82						
	0.1	34.75	5 45	.016	0.1	0 30	.014–	
9	0	25.60						
	0.1	33.45	6 10	.016	0.1	0 30	.014–	Another slight seam.
10	0	24.00						
	0.1	32.00	3 00	.015	0.1	0 30	.014–	
11	0	22.50						
	0.1	30.47	7 00	.016	0.1	0 30	.0145	
12	0	21.05						
	0.1	29.35	8 20	.0165	0.1	0 30	.0145	
13	0	19.65						
	.09	25.00	(Broke.)					

NOTE TO TABLES 31 TO 41.

In order that these tables may be more readily understood, the course of experiment they record will be here expressed in words, so far as is necessary to illustrate the mode of operating.

Take, as an example, the experiment given in table 32:

The specimen was first gradually twisted to the left, the time of applying the strain being 4 minutes and the extent of torsion 1-10 of a turn. The strain required to do this was 25.24 pounds, applied 1 foot from the center of motion, and the time of its application (before mentioned) such that the specimen had nearly ceased yielding. The specimen was then released from strain, and was found to have sprung back 10-1000 of a turn.

This statement includes all that is entered in the table as occurring under the first application of *torsion to the left.*

Torsion was now applied in the reverse direction, and carried to the extent of 1-10 of a turn to the right of the original starting-point, requiring in all, of course, 1-5 of a turn in the right-hand direction less the resilience before noted. The strain required to do this was applied in 30 seconds; but its amount was not readily ascertainable by the means at hand, and was not taken. When again released, the specimen sprang back 5-1000 of a turn.

We have now completed the record in the first line of the table.

Again reversing the torsion, *i. e.*, making the *second application* of torsion to the left, it was carried to the central position, (in which the specimen is deprived of twist,) the strain requisite for this purpose being 29 pounds, and farther, in the same direction, until, in 5½ minutes, a left-hand torsion of 1-10 of a turn had been reached again, requiring a strain of 33.10 pounds. Again released from torsional strain, the specimen was found to have a resilience of 11-1000 of a turn.

Torsion to the right was now applied, and carried 1-10 of a turn to the right of the central position. Time in which this was done, 30 seconds. Released, the specimen sprang back 10-1000 of a turn.

This completes the third line of the table.

Succeeding applications of torsion were conducted in the same way, and their results are similarly recorded.

NOTE TO TABLES 42 TO 51.

The relations between elastic resistance, torsion, and resilience, as developed in the experiments here recorded, are represented graphically in plates 7 to 23. The diagrams, representing each a single experiment, present the points (surrounded by small circles) from which the curves were formed. The want of perfect coincidence between the points and curves of mean direction must be attributed chiefly to the influence of time, *i. e.*, the continuance of the strains by which the work was done, which unavoidably varied in the course of the experiments.

In all the diagrams *resilience* is represented by the *red lines*.

Plates 15 and 23 combine the results of single experiments to present comparisons of the characteristic curves of the several specimens.

TABLE 42.—*Experiment on the development of elastic resistance and resilience by torsion. Wire drawn from Martin steel manufactured by the New Jersey Steel and Iron Co.*

[Mark, C J.—Experiment No. 1353.]

Strain applied 1 foot from center.	Torsion.		Time of application of strain.	Resilience.	Remarks.
	Under strain.	Released.			
Lbs.	*Turns.*	*Turns.*	*m. s.*	*Turns.*	
13.15	.0262	.0029	9 23	.0233	Length of wire between clamps, 10 inches; form, square; annealed at a temperature between the melting-points of bronze and copper. Measurement of cross-section, 0''.2981 x 0''.2993; measurement of diagonals before twisting, 0''.401 and 0''.401; measurement of diagonals after twisting, 0''.394 and 0''.394; contraction in 10 inches of length, 0''.020.
15.90	.05	.0204	0 23	.0296	
16.31	.100	.0695	0 15	.0305	
17.47	.20	.1653	0 13	.0347	
19.05	.30	.2589	0 16	.0411	
20.76	.40	.355	0 20	.045	
22.14	.50	.452	0 18	.048	
23.66	.60	.5468	0 14	.0532	
24.74	.70	.644	0 14	.056	
25.85	.80	.7413	0 13	.0587	
26.94	.90	.8499	0 13	.0511	
27.75	1.001	.9374	0 10	.0626	
28.63	1.100	1.0339	0 15	.0661	
29.45	1.20	1.133	0 13	.067	
30.05	1.301	1.230	0 14	.071	
30.76	1.40	1.3295	0 13	.0705	After intermission of one hour torsion stood 1.3285.
31.53	1.50	1.428	0 12	.072	
32.08	1.599	1.5269	0 11	.0721	
32.65	1.70	1.6255	0 10	.0745	
33.14	1.80	1.7241	0 08	.0759	
33.66	1.90	1.8239	0 08	.0761	
34.08	2.00	1.922	0 10	.078	
34.54	2.10	2.021	0 09	.079	
35.00	2.20	2.120	0 08	.080	
35.38	2.30	2.2195	0 08	.0805	
35.76	2.40	2.3195	0 09	.0805	
36.07	2.50	2.418	0 08	.082	
36.50	2.60	2.5176	0 08	.0824	
36.86	2.701	2.6171	0 09	.0829	
37.23	2.80	2.7162	0 08	.0838	
37.57	2.90	2.8162	0 09	.0838	
37.95	3.00	2.915	0 10	.085	
38.19	3.10	3.0153	0 09	.0847	
38.43	3.20	3.114	0 09	.086	
38.82	3.30	3.2136	0 08	.0864	
39.09	3.40	3.313	0 09	.087	
39.31	3.50	3.4115	0 09	.0885	
39.61	3.60	3.5123	0 08	.0877	
39.90	3.70	3.611	0 08	.089	
40.23	3.801	3.711	0 09	.090	
40.40	3.90	3.812	0 08	.088	
40.68	4.00	3.911	0 08	.089	
40.86	4.10	4.0095	0 08	.0905	
41.12	4.20	4.1095	0 08	.0905	
41.36	4.30	4.2086	0 08	.0914	
41.62	4.40	4.309	0 08	.091	
41.80	4.50	4.4082	0 08	.0918	
41.97	4.60	4.5078	0 08	.0922	
42.18	4.70	4.6071	0 07	.0929	
42.42	4.80	4.7075	0 08	.0925	
42.54	4.90	4.808	0 09	.092	
42.72	5.00	4.9065	0 08	.0935	
42.98	5.101	5.007	0 07	.094	
43.19	5.20	5.1062	0 08	.0938	
43.31	5.30	5.2066	0 07	.0934	
43.49	5.40	5.3065	0 07	.0935	
43.63	5.50	5.4053	0 06	.0947	
43.75	5.60	5.5064	0 07	.0936	
44.00	5.699	5.6049	0 07	.0941	
44.14	5.80	5.705	0 06	.095	
44.28	5.90	5.805	0 07	.095	
44.40	6.00	5.904	0 08	.096	
44.58	6.10	6.004	0 06	.096	
44.75	6.20	6.105	0 08	.095	
44.89	6.30	6.204	0 06	.096	
45.00	6.40	6.3037	0 05	.0963	
45.14	6.501	6.4034	0 07	.0976	
45.27	6.60	6.504	0 08	.096	
45.42	6.70	6.604	0 08	.096	
45.44	6.743	(Broke.)	0 03	....	

TABLE 43.—*Experiment on the development of elastic resistance and resilience by torsion. Wire drawn from crucible cast steel manufactured by Hussey, Welles & Co.*

[Mark, H W co 4.—Experiment No. 1354.]

Strain applied 1 foot from center.	Torsion.		Time of application of strain.	Resilience.	Remarks.
	Under strain.	Released.			
Lbs.	*Turns.*	*Turns.*	*m. s.*	*Turns.*	
13. 60	. 026	. 003	9 00	. 023	Length of wire between clamps, 10 inches; form, square; annealed at a temperature between the melting-points of bronze and copper; measurement of cross-section, 0. 2989 x 0. 300; measurement of diagonals before twisting, 0. 4035 and 0. 403; measurement of diagonals after twisting, 0. 400 and 0. 401; contraction in 10 inches of length could not be taken because fracture occurred between measuring-points.
15. 21	. 050	. 0218	0 25	. 0282	
15. 96	. 10	. 067	0 12	. 033	
18. 92	. 20	. 1576	0 18	. 0424	
21. 82	. 30	. 249	0 18	. 051	
24. 46	. 40	. 3416	0 18	. 0584	
26. 60	. 50	. 4365	0 15	. 0635	
28. 47	. 60	. 5295	0 14	. 0705	
30. 00	. 70	. 6257	0 13	. 0743	
31. 45	. 80	. 7219	0 12	. 0781	
32. 69	. 90	. 8195	0 10	. 0805	
33. 73	1. 00	. 917	0 10	. 083	
34. 56	1. 10	1. 0139	0 11	. 0861	
35. 43	1. 20	1. 113	0 11	. 087	
36. 25	1. 30	1. 2085	0 12	. 0915	
36. 94	1. 40	1. 3067	0 11	. 0933	
37. 53	1. 50	1. 4065	0 11	. 0935	
38. 00	1. 60	1. 504	0 11	. 096	Saturday night.
38. 73	1. 70	1. 6033	0 10	. 0967	Monday morning; torsion released, 1. 60.
39. 68	1. 80	1. 700	0 10	. 100	
40. 09	1. 90	1. 785	0 09	. 115	
40. 60	2. 00	1. 883	0 09	. 117	
41. 00	2. 10	1. 978	0 09	. 122	
41. 46	2. 199	2. 0964	0 08	. 1026	
41. 97	2. 30	2. 1974	0 09	. 1026	
42. 26	2. 40	2. 2964	0 08	. 1036	
42. 75	2. 501	2. 394 ?	0 08	. 107	
43. 00	2. 60	2. 495 ?	0 09	. 105	
43. 50	2. 70	2. 5935	0 09	. 1065	
43. 80	2. 80	2. 6932	0 08	. 1068	
44. 21	2. 90	2. 7917	0 08	. 1083	
44. 48	3. 00	2. 8917	0 09	. 1083	
44. 88	3. 101	2. 990	0 08	. 111	
45. 30	3. 20	3. 0915	0 09	. 1085	
45. 49	3. 30	3. 1898	0 08	. 1102	
45. 73	3. 40	3. 2895	0 08	. 1105	
46. 10	3. 50	3. 389	0 08	. 111	
46. 42	3. 60	3. 489	0 08	. 111	
46. 65	3. 70	3. 5885	0 08	. 1115	
46. 92	3. 80	3. 687	0 08	. 113	
47. 30	3. 90	3. 789	0 08	. 111	
47. 45	4. 00	3. 888	0 08	. 112	
47. 91	4. 10	3. 9878	0 08	. 1122	
48. 01	4. 20	4. 0865	0 08	. 1135	
48. 29	4. 30	4. 187	0 08	. 113	
48. 56	4. 40	4. 2872	0 08	. 1128	
48. 80	4. 50	4. 387	0 08	. 113	
48. 89	4. 60	4. 489	0 08	. 111	Did not again raise the same weight.

TABLE 44.—*Experiment on the development of elastic resistance and resilience by torsion. Wire drawn from crucible cast steel manufactured by the Atlantic Steel Company.*

[Mark, A co 91.—Experiment No. 1353.]

Strain applied 1 foot from center.	Torsion.		Time of application of strain.	Resilience.	Remarks.
	Under strain.	Released.			
Lbs.	*Turns.*	*Turns.*	*m. s.*	*Turns.*	
15.10	0.0286	0.003	5 35	.0256	Length of wire between clamps, 10 inches; form, square; annealed at a temperature between the melting-points of bronze and copper; measurement of cross-section 0.3019 x 0.299; measurement of diagonals before twisting, 0.406 and 0.402; measurement of diagonals after twisting, 0.397 and 0.399; contraction in 10 inches of length, 0.035.
19.69	0.050	0.0159	0 38	.0341	
21.10	0.10	0.0614	0 15	.0386	
22.32	0.20	0.1595	0 15	.0405	
24.37	0.30	0.2514	0 15	.0486	
26.30	0.40	0.3465	0 15	.0535	
28.12	0.50	0.442	0 12	.058	
29.90	0.60	0.5395	0 10	.0605	
31.31	0.70	0.636	0 10	.064	
32.61	0.80	0.7333	0 09	.0667	
33.84	0.90	0.8295	0 10	.0705	
34.90	1.00	0.927	0 09	.073	
35.89	1.10	1.024	0 09	.076	
36.72	1.20	1.123	0 11	.077	
37.54	1.30	1.220	0 09	.080	
38.29	1.40	1.319	0 09	.081	
39.00	1.50	1.418	0 09	.082	
39.63	1.60	1.517	0 09	.083	
40.39	1.699	1.614	0 10	.085	
40.88	1.80	1.7136	0 09	.0864	
41.38	1.90	1.8135	0 08	.0865	
41.95	2.00	1.911	0 09	.089	
42.32	2.10	2.011	0 09	.089	
42.86	2.20	2.1107	0 09	.0893	
43.24	2.30	2.2105	0 08	.0895	
43.60	2.40	2.3089	0 10	.0911	
44.08	2.50	2.4084	0 09	.0916	
44.48	2.60	2.5079	0 09	.0921	
44.86	2.70	2.6072	0 09	.0928	
45.17	2.80	2.707	0 08	.093	
45.53	2.90	2.8062	0 09	.0938	
45.84	3.00	2.9045	0 09	.0955	
46.42	3.10	3.0052	0 09	.0948	
46.69	3.20	3.1056	0 08	.0944	
46.99	3.30	3.204	0 08	.096	
47.09	3.40	3.3025	0 09	.0975	
47.39	3.50	3.4025	0 08	.0975	
47.66	3.60	3.5017	0 09	.0983	
47.93	3.70	3.601	0 09	.099	
48.20	3.80	3.703	0 08	.097	
48.44	3.90	3.8023	0 08	.0977	
48.65	4.00	3.9005	0 08	.0995	
48.82	4.10	3.9995	0 08	.1005	
49.19	4.20	4.101	0 08	.099	
49.31	4.30	4.1995	0 09	.1005	
49.62	4.40	4.3005	0 09	.0995	
49.74	4.50	4.3995	0 08	.1005	
50.32	4.60	4.500	0 09	.100	
50.34	4.70	4.599	0 08	.101	
50.36	4.80	4.6983	0 09	.1017	
50.50	4.90	4.7985	0 09	.1015	
50.67	5.00	4.8985	0 09	.1015	
50.89	5.10	4.9988	0 09	.1012	
51.00	5.20	5.098	0 08	.102	
51.11	5.30	5.1977	0 09	.1023	
51.35	5.40	5.298	0 09	.102	
51.48	5.50	5.3968	0 08	.1032	
51.65	5.60	5.498	0 09	.102	
51.79	5.70	5.597	0 09	.103	
51.94	5.80	5.6968	0 09	.1032	
52.06	5.899	5.7965	0 08	.1025	
52.22	6.00	5.897	0 08	.103	
52.36	6.10	5.997	0 09	.103	
52.47	6.20	6.097	0 08	.103	
52.57	6.30	6.1965	0 10	.1035	
52.68	6.40	6.2968	0 09	.1032	
52.80	6.50	6.396	0 09	.104	
....	6.515	(Broke.)	....	....	Without again raising 52 80 pounds.

TABLE 45.—*Experiment on the development of elastic resistance and resilience by torsion. Wire drawn from crucible cast steel manufactured by the Atlantic Steel Company.*

[Mark, A co 138.—Experiment No. 1356.]

Strain applied 1 foot from center.	Torsion.		Time of application of strain.	Resilience.	Remarks.
	Under strain.	Released.			
Lbs.	*Turns.*	*Turns.*	*m. s.*	*Turns.*	
14. 80	0. 026	0. 001	4 45	. 025	Length of wire between clamps, 10 inches; form, square; annealed at a temperature between the melting-points of bronze and copper; measurement of cross-section, 0.298 x 0.295; measurement of diagonals before twisting, 0.415 and 0.414; measurement of diagonals after twisting, 0.411 and 0.4115; contraction in 10 inches of length, 0.040.
16. 60	0. 0285	0. 001	1 40	. 0284	
18. 00	0. 032	0. 0024	1 20	. 0296	
20. 49	0. 050	0. 016	0 25	. 0340	
21. 15	0. 10	0. 064	0 17	. 036	
22. 17	0. 20	0. 161	0 17	. 039	
23. 57	0. 30	0. 2558	0 15	. 0442	
25. 25	0. 40	0. 3517	0 12	. 0483	
26. 91	0. 50	0. 4478	0 12	. 0522	
28. 08	0. 60	0. 544	0 11	. 056	
29. 40	0. 70	0. 6418	0 11	. 0582	
30. 53	0. 80	0. 739	0 12	. 061	
31. 61	0. 90	0. 8375	0 13	. 0625	
32. 57	1. 00	0. 935	0 12	. 065	
33. 33	1. 101	1. 0333	0 11	. 0677	
34. 10	1. 20	1. 1314	0 10	. 0686	
34. 81	1. 30	1. 2295	0 10	. 0705	
35. 55	1. 40	1. 3285	0 10	. 0715	
36. 20	1. 50	1. 427	0 09	. 073	
36. 78	1. 60	1. 526	0 09	. 074	
37. 37	1. 701	1. 624	0 10	. 076	
37. 88	1. 80	1. 724	0 10	. 076	
38. 38	1. 90	1. 8223	0 10	. 0777	
38. 78	2. 00	1. 9213	0 10	. 0787	
39. 29	2. 10	2. 021	0 10	. 079	
39. 92	2. 20	2. 12	0 09	. 080	
40. 34	2. 30	2. 219	0 09	. 081	
40. 62	2. 40	2. 319	0 09	. 081	
41. 04	2. 50	2. 418	0 10	. 082	
41. 38	2. 60	2. 517	0 09	. 083	
41. 68	2. 70	2. 6165	0 09	. 0835	
41. 98	2. 80	2. 717	0 09	. 083	
42. 31	2. 90	2. 8165	0 10	. 0835	
42. 72	3. 00	2. 9148	0 09	. 0852	
42. 98	3. 10	3. 0139	0 09	. 0861	
43. 33	3. 20	3. 114	0 09	. 086	
43. 68	3. 30	3. 2139	0 09	. 0861	
43. 96	3. 40	3. 315	0 09	. 085	
44. 24	3. 50	3. 4119	0 09	. 0881	
44. 55	3. 60	3. 5133	0 09	. 0867	
44. 78	3. 70	3. 612	0 10	. 088	
45. 00	3. 80	3. 712	0 09	. 088	
45. 19	3. 90	3. 8118	0 08	. 0882	
45. 83	4. 00	3. 91	0 10	. 09	
45. 85	4. 10	4. 010	0 09	. 09	
45. 98	4. 20	4. 1165	0 09	. 0835	Broke without raising the weight again.

TABLE 46.—*Experiment on the development of elastic resistance and resilience by torsion. Wire drawn from Martin steel, manufactured by the New Jersey Steel and Iron Company.*

[Mark O.—Experiment No. 1357.]

Strain applied 1 foot from center.	Torsion.		Time of application of strain.	Resilience.	Remarks.
	Under strain.	Released.			
Lbs.	*Turns.*	*Turns.*	*m. s.*	*Turns.*	
12.43	0.0244	0.0025	3 00	.0219	Length of wire between clamps 10 inches; form, square; annealed at a temperature between the melting-points of bronze and copper. Measurement of cross-section, 0.301 x 0.3014; measurement of diagonals before twisting, 0.399 and 0.398; measurement of diagonals after twisting, 0.393 and 0.391; contraction in 10 inches of length, 0.041.
14.30	0.05	0.027	0 17	.023	
14.58	0.10	0.0766	0 09	.0234	
14.94	0.20	0.172	0 09	.028	
15.60	0.30	0.2695	0 09	.0305	
16.62	0.40	0.3688	0 10	.0312	
17.58	0.50	0.4655	0 10	.0345	
18.47	0.60	0.5636	0 10	.0364	
19.28	0.20	0.6614	0 10	.0386	
20.02	0.80	0.7595	0 10	.0405	
20.79	0.90	0.8583	0 10	.0417	
21.53	1.00	0.9567	0 09	.0433	
22.24	1.10	1.0545	0 09	.0455	
22.81	1.199	1.152	0 08	.047	
23.42	1.30	1.2517	0 09	.0483	
23.97	1.40	1.351	0 09	.049	
24.55	1.50	1.4495	0 09	.0505	
25.05	1.60	1.5495	0 09	.0505	
25.51	1.70	1.6475	0 09	.0525	
25.91	1.80	1.7466	0 09	.0534	
26.41	1.90	1.8462	0 09	.0538	
26.77	2.00	1.9435	0 09	.0565	
27.20	2.10	2.0435	0 09	.0565	
27.57	2.20	2.1425	0 09	.0575	
27.96	2.30	2.242	0 09	.058	
28.35	2.40	2.342	0 08	.058	
28.68	2.50	2.4415	0 08	.0585	
29.00	2.601	2.542	0 09	.059	
29.32	2.70	2.640	0 08	.060	
29.63	2.80	2.738	0 08	.062	
29.94	2.90	2.8385	0 09	.0615	
30.29	3.00	2.939	0 09	.061	
30.52	3.10	3.0392	0 09	.0608	
30.77	3.20	3.1385	0 09	.0615	
31.15	3.30	3.238	0 09	.062	
31.30	3.40	3.3372	0 09	.0628	
31.58	3.50	3.437	0 08	.063	
31.79	3.60	3.5373	0 09	.0627	
32.05	3.70	3.6365	0 09	.0635	
32.32	3.80	3.735	0 09	.065	
32.59	3.90	3.835	0 09	.065	
32.81	4.00	3.9345	0 09	.0665	
32.96	4.10	4.0337	0 09	.0663	
33.27	4.20	4.134	0 08	.066	
33.42	4.30	4.234	0 08	.066	
33.63	4.40	4.3335	0 08	.0665	
33.88	4.50	4.4325	0 09	.0675	
34.02	3.60	4.5335	0 09	.0665	
34.22	4.70	4.632	0 08	.068	
34.41	4.80	4.732	0 09	.068	
34.59	4.899	4.832	0 08	.067	
34.73	5.00	4.9315	0 08	.0685	
34.90	5.10	5.031	0 08	.069	
35.08	5.20	5.1315	0 08	.0685	
35.23	5.30	5.2313	0 08	.0687	
35.44	5.40	5.3309	0 08	.0691	
35.54	5.50	5.429	0 08	.071	
35.69	5.60	5.5305	0 08	.0695	
35.84	5.70	5.6305	0 68	.0695	
35.96	5.80	5.730	0 08	.070	
36.10	5.90	5.829	0 08	.071	
36.32	6.00	5.929	0 09	.071	
36.53	6.10	6.029	0 09	.071	
36.64	6.20	6.130	0 08	.070	
36.83	6.30	6.2295	0 08	.0705	
36.92	6.40	6.3295	0 08	.0705	
37.00	6.50	6.4285	0 08	.0715	
37.11	6.60	6.5285	0 08	.0715	
37.24	6.70	6.628	0 08	.072	

TABLE 46.—*Experiment on the development of elastic resistance, &c., of a wire drawn from Martin steel, manufactured by the New Jersey Steel and Iron Company*—Continued.

[Mark O.—Experiment No. 1537.]

Strain applied 1 foot from center.	Torsion.		Time of application of strain.	Resilience.	Remarks.
	Under strain.	Released.			
Lbs.	*Turns.*	*Turns.*	*m. s.*	*Turns.*	
37.32	6.80	6.7283	0 07	.0717	
37.40	6.90	6.8265	0 08	.0735	
37.50	7.00	6.928	0 08	.072	
37.58	7.10	7.0273	0 08	.0727	
37.71	7.201	7.1275	0 08	.0735	
37.81	7.30	7.2275	0 08	.0725	
....	3.60	(Broke.)	0 05	....	Did not raise the weight again.

TABLE 47.—*Experiment on the development of elastic resistance and resilience by torsion. Wire drawn from Naylor & Co.'s "best cast steel," (for tools,) ⅜-inch hammered bar.*

[Mark, N co T* 1.—Experiment No. 1358.]

Strain applied 1 foot from center.	Torsion.		Time of application of strain.	Resilience.	Remarks.
	Under strain.	Released.			
Lbs.	*Turns.*	*Turns.*	*m. s.*	*Turns.*	
16. 45	0. 0385	0. 0088	4 30	. 0297	Length of wire between clamps, 10 inches; form, square; annealed at a temperature between the melting-points of bronze and copper. Measurement of cross-section, 0.2986 x 0.300; measurement of diagonals before twisting, 0.413 and 0.413; measurement of diagonals after twisting, 0.411 and 0.411; contraction in 10 inches of length, 0.087. Specimen being a little winding the venier could not be set at 0.; set at .005.
17. 21	0. 050	0. 0178	0 19	. 0372	
18. 88	0. 10	0. 0648	0 14	. 0452	
21. 64	0. 20	0. 151	0 20	. 049	
24. 80	0. 30	0. 241	0 18	. 059	
27. 71	0. 40	0. 3328	0 21	. 0672	
30. 00	0. 50	0. 4263	0 22	. 0737	
32. 15	0. 60	0. 5195	0 17	. 0805	
34. 03	0. 70	0. 614	0 16	. 086	
35. 45	0. 80	0. 710	0 13	. 090	
36. 72	0. 90	0. 8069	0 12	. 0931	
37. 86	1. 00	0. 904	0 10	. 096	
38. 74	1. 10	1. 002	0 10	. 098	
39. 66	1. 20	1. 101	0 10	. 099	
40. 42	1. 30	1. 1972	0 10	. 0128	
41. 00	1. 40	1. 295	0 09	. 105	
41. 71	1. 50	1. 3933	0 10	. 1067	
42. 44	1. 60	1. 4935	0 10	. 1065	
42. 90	1. 70	1. 591	0 09	. 109	
43. 49	1. 80	1. 690	0 09	. 110	
43. 91	1. 90	1. 790	0 09	. 110	
44. 37	2. 00	1. 889	0 09	. 111	
44. 95	2. 10	1. 984	0 09	. 116	
45. 37	2. 201	2. 0877	0 08	. 1133	
45. 69	2. 30	2. 160	0 09	. 140	
46. 00	2. 40	2. 2855	0 10	. 1145	
46. 53	2. 50	2. 3845	0 09	. 1155	
46. 91	2. 60	2. 4837	0 09	. 1163	
47. 41	2. 70	2. 585	0 09	. 115	
47. 68	2. 80	2. 683	0 09	. 117	
47. 92	2. 90	2. 782	0 10	. 118	
48. 42	3. 00	2. 882	0 10	. 118	
48. 59	3. 101	2. 9817	0 09	. 1191	
48. 90	3. 20	3. 0815	0 08	. 1185	
49. 18	3. 30	3. 181	0 09	. 119	
49. 50	3. 40	3. 280	0 09	. 120	
49. 77	3. 50	3. 380	0 09	. 120	
50. 00	3. 60	3. 4809	0 08	. 1191	
50. 54	3. 70	3. 5805	0 09	. 1195	
....	3. 769	(Broke.)	0 05	....	Did not raise weight again.

TABLE 48.—*Experimnt on the development of elastic resistance and resilience by torsion. Wire drawn from cemented cast steel manufactured for test and furnished by Messrs. Naylor & Co.*

[Mark, N oo 1 S.—Experiment No. 1359.]

Strain applied 1 foot from center.	Torsion.		Time of application of strain.	Resilience.	Remarks.
	Under strain.	Released.			
Lbs.	*Turns.*	*Turns.*	*m. s.*	*Turns.*	
13.00	0.0245	0.0022	4 00	.0113	Length of wire between clamps, 10 inches; form, square; annealed at a temperature between the melting-points of bronze and copper. Measurement of cross-section, 0.3014 x 0.302: measurement of diagonals before twisting, 0.409 and 0.4097; measurement of diagonals after twisting, 0.404 and 0.404; contraction in 10 inches of length, 0.047.
15.00	0.050	0.025	0 20	.025	
15.31	0.10	0.070	0 10	.030	
16.76	0.20	0.1655	0 15	.0345	
18.99	0.30	0.2585	0 16	.0415	
20.85	0.40	0.3538	0 16	.0402	
22.72	0.50	0.450	0 15	.050	
24.17	0.60	0.5445	0 13	.0555	
25.65	0.70	0.642	0 11	.058	
26.85	0.80	0.739	0 10	.061	
27.85	0.901	0.837	0 09	.064	
28.85	1.00	0.934	0 09	.066	
29.70	1.10	1.0317	0 10	.0683	
30.50	1.20	1.130	0 09	.070	
31.22	1.30	1.228	0 10	.072	
31.90	1.40	1.3263	0 09	.0737	
32.62	1.50	1.4267	0 09	.0733	
33.00	1.60	1.525	0 09	.075	
33.60	1.70	1.6235	0 09	.0775	
34.14	1.80	1.722	0 12	.078	
34.53	1.90	1.821	0 10	.079	
35.00	2.00	1.920	0 09	.080	
35.54	2.10	2.0195	....	.0805	
35.95	2.20	2.1185	0 09	.0815	
36.30	2.30	2.2179	0 09	.0821	
36.74	2.401	2.3175	0 09	.0835	
37.14	2.50	2.4163	0 09	.0837	
37.46	2.60	2.5162	0 09	.0838	
37.80	2.70	2.615	0 09	.085	
38.17	2.80	2.7149	0 09	.0851	
38.49	2.90	2.8149	0 09	.0851	
38.87	3.00	2.913	0 09	.087	
39.14	3.10	3.0136	0 09	.0864	
39.50	3.20	3.1115	0 09	.0885	
39.67	3.30	3.2113	0 08	.0887	
40.40	3.40	3.3110	0 09	.0890	
40.24	3.50	3.410	0 09	.090	
40.57	3.60	3.510	0 09	.090	
40.80	3.70	3.609	0 09	.091	
41.00	3.80	3.710	0 10	.090	
41.30	3.90	3.809	0 10	.091	
41.47	4.00	3.909	0 09	.091	
41.73	4.10	4.001	0 09	.10	
41.95	4.20	4.108	0 09	.092	
42.44	4.30	4.2074	0 10	.0924	
42.57	4.40	4.3073	0 10	.0927	
42.76	4.50	4.408	0 09	.092	
42.94	4.60	4.508	0 09	.092	
43.20	4.70	4.6076	0 09	.0224	
43.40	4.80	4.7069	0 09	.0931	
43.57	4.90	4.8064	0 09	.0936	
43.62	5.00	4.9050	0 08	.0150	
43.87	5.101	5.005	0 09	.095	
44.00	5.20	5.1045	0 10	.0955	
44.25	5.30	5.2043	0 09	.0957	
44.34	5.40	5.306	0 09	.094	
....	5.419	(Broke.)	0 05	....	Did not again raise the weight.

TABLE 49.—*Experiment on the development of elastic resistance and resilience by torsion. Wire drawn from iron for "gun-screw wire," manufactured by the Trenton Iron Company.*

[Mark, C H co 5 I.—Experiment No. 1360.]

Strain applied 1 foot from center.	Torsion.		Time of application of strain.	Resilience.	Remarks.
	Under strain.	Released.			
Lbs.	*Turns.*	*Turns.*	*m. s.*	*Turns.*	
9.23	0.0215	0.0032	4 00	.0183	Length of wire between clamps, 10 inches. Form, square; annealed at a temperature between the melting-points of bronze and copper. Measurement of cross-section, 0.2918 x 0.2917; measurement of diagonals before twisting, 0.393 and 0.391; measurement of diagonals after twisting, 0.386 and 0.389; contraction in 10 inches of length, 0.032.
10.48	0.050	0.0305	0 22	.0195	
10.70	0.150	0.129	0 20	.021	
11.00	0.20	0.1778	0 08	.0222	
11.83	0.30	0.274	0 12	.026	
12.67	0.40	0.3739	0 10	.0261	
13.37	0.50	0.4719	0 10	.0281	
14.00	0.60	0.5695	0 10	.0305	
14.68	0.70	0.668	0 10	.032	
15.31	0.80	0.768	0 10	.032	
15.82	0.90	0.8655	0 10	.0345	
16.34	1.00	0.965	0 10	.035	
16.84	1.10	1.0632	0 11	.0368	
17.34	1.20	1.162	0 11	.038	
17.79	1.30	1.260	0 10	.038	
18.30	1.40	1.3595	0 10	.0405	
18.66	1.50	1.459	0 10	.041	
19.10	1.60	1.5585	0 10	.0415	
19.45	1.70	1.6572	0 10	.0428	
19.87	1.80	1.757	0 10	.043	
20.35	1.899	1.856	0 10	.043	
22.00	2.00	1.957	0 12	.043	
22.00	2.10	2.056	0 10	.044	
21.82	2.20	2.153	0 09	.047	
21.98	2. 0	2.2518	0 08	.0482	
22.27	2.40	2.3514	0 09	.0486	
22.53	2.50	2.4505	0 08	.0495	
22.84	2.60	2.5505	0 08	.0495	
23.00	2.70	2.6492	0 09	.0508	
23.29	2.80	2.7491	0 08	.0509	
23.55	2.90	2.8428	0 08	.0512	
23.79	3.00	2.948	0 08	.052	
24.00	3.10	3.0475	0 08	.0325	
24.27	3.20	3.1476	0 09	.0524	
24.53	3.30	3.2468	0 08	.0532	
24.71	3.40	3.3468	0 08	.0532	
24.93	3.50	3.446	0 07	.054	
25.19	3.60	3.546	0 08	.054	
25.38	3.70	3.6453	0 08	.0547	
25.56	3.80	3.7453	0 08	.0547	
25.98	3.90	3.845	0 07	.055	
26.15	4.00	3.9436	0 10	.0564	
26.43	4.10	4.0445	0 08	.0555	
26.60	4.20	4.144	0 09	.056	
26.79	4.30	4.2438	0 08	.0562	
26.93	4.40	4.343	0 07	.057	
27.06	4.50	4.446	0 07	.054	
27.33	4.60	4.542	0 08	.058	
27.48	4.70	4.6413	0 08	.0587	
27.57	4.80	4.7405	0 08	.0595	
27.73	4.90	4.841	0 07	.059	
27.90	5.00	4.940	0 08	.060	
28.16	5.101	5.040	0 09	.061	
28.31	5.20	5.141	0 08	.059	
28.42	5.30	5.24	0 08	.06	
28.55	5.40	5.34	0 08	.06	
28.64	5.50	5.439	0 08	.061	
28.88	4.60	5.539	0 08	.061	
28.98	5.70	5.639	0 08	.061	
29.06	5.80	5.739	0 08	.061	
29.21	5.90	5.839	0 08	.061	
29.30	6.00	5.9385	0 07	.0615	
29.38	6.101	6.0385	0 07	.0615	
29.53	6.20	6.1385	0 08	.0615	
29.70	6.30	6.236	0 09	.064	
29.80	6.40	6.3375	0 08	.0625	

TABLE 49.—*Experiment on the development of elastic resistance, &c., of a wire drawn from iron for "gun-screw wire," manufactured by the Trenton Iron Company*—Continued.

Strain applied 1 foot from center.	Torsion.		Time of application of strain.	Resilience.	Remarks.
	Under strain.	Released.			
Lbs.	*Turns.*	*Turns.*	*m. s.*	*Turns.*	
29.89	6.50	6.4378	0 09	.0622	
29.96	6.60	6.537	0 08	.063	
30.10	6.70	6.6375	0 09	.0625	
30.20	6.80	6.7375	0 09	.0625	
30.23	6.8515	(Broke.)	0 05	....	

TABLE 50.—*Experiment on the development of elastic resistance and resilience by torsion. Wire drawn from Lake Superior copper, refined and rolled at the Washington navy-yard.*

[Experiment No. 1361.]

Strain applied 1 foot from center.	Torsion.		Time of application of strain.	Resilience.	Remarks.
	Under strain.	Released.			
Lbs.	*Turns.*	*Turns.*	*m. s.*	*Turns.*	
2.25	0.0242	0.015	3 00	.0092	Length of wire between clamps 10 inches; form, square; annealed at a temperature between the melting-points of bronze and copper. Measurement of cross-section, 0.2946 x 0.293; measurement of diagonals before twisting, 0.395 and 0.39553; measurement of diagonals after twisting, 0.388 and 0.3865; contraction in 10 inches of length, 0.30.
2.71	0.050	0.038	0 16	.012	
3.13	0.10	0.087	0 11	.013	
3.67	0.20	0.184	0 17	.016	
4.21	0.30	0.2815	0 14	.0185	
4.58	0.40	0.379	0 16	.021	
5.00	0.50	0.4775	0 14	.0225	
5.43	0.60	0.5774	0 15	.0226	
5.76	0.70	0.6745	0 12	.0255	
6.22	0.80	0.773	0 14	.027	
6.44	0.90	0.872	0 12	.028	
6.78	1.00	0.9695	0 12	.0305	
7.08	1.10	1.0675	0 12	.0325	Several small seams show at different places.
7.40	1.20	1.168	0 10	.032	
7.69	1.30	1.2668	0 12	.0332	
7.96	1.40	1.366	0 12	.034	
8.24	1.50	1.465	0 13	.035	
8.52	1.60	1.563	0 10	.037	
8.75	1.70	1.6628	0 10	.0372	
9.05	1.80	1.762	0 10	.038	
9.24	1.90	1.8615	0 09	.0385	
9.48	2.00	1.9613	0 09	.0387	
9.70	2.10	2.060	0 09	.040	
9.90	2.20	2.1595	0 09	.0405	
10.10	2.30	2.259	0 10	.041	
10.33	2.40	2.3575	0 10	.0425	
10.52	2.50	2.4582	0 09	.0418	
10.73	2.60	2.5578	0 09	.0422	
10.89	2.70	2.6573	0 10	.0427	Missed strain at torsion of 2.80.
11.21	2.90	2.8553	0 13	.0447	
11.37	3.00	2.956	0 10	.044	
11.54	3.10	3.0545	0 09	.0455	
11.72	3.20	3.1539	0 09	.0461	
11.89	3.30	3.2535	0 09	.0465	
12.09	3.40	3.352	0 08	.048	
12.18	3.50	3.4525	0 08	.0475	
12.33	3.601	3.5534	0 09	.0476	
12.47	3.70	3.6512	0 08	.0488	
12.61	3.80	3.751	0 09	.049	
12.75	3.90	3.851	0 08	.049	
12.87	4.00	3.950	0 09	.050	
13.01	4.10	4.050	0 09	.050	
13.11	4.20	4.150	0 09	.050	
13.28	4.30	4.2495	0 08	.0505	
13.40	4.40	4.3495	0 09	.0505	
13.54	4.50	4.4495	0 09	.0505	
13.62	4.60	4.549	0 08	.051	
13.74	4.70	4.685	0 09	.015	
13.83	4.80	4.785	0 08	.015	
13.98	4.90	4.888	0 08	.011	
14.06	5.00	4.948	0 08	.052	
14.16	5.101	5.0475	0 08	.0525	
14 32	5.20	5.1474	0 08	.0526	
14.39	5.30	5.247	0 08	.053	
14.47	5.40	5.3472	0 08	.0528	
14.55	5.50	5.4468	0 08	.0532	
14.64	5.60	5.5469	0 08	.0531	
14.71	5.70	5.6455	0 08	.0545	
14.80	5.80	5.746	0 09	.054	
14.90	5.90	5.8465	0 09	.0535	
14.98	6.00	5.9469	0 09	.0531	
15.07	6.10	6.045	0 09	.055	
15.11	6.20	6.146	0 08	.054	
15.19	6.30	6.245	0 09	.055	
15.27	6.40	6.34 45	0 08	.0555	
15.36	6.50	6.415	0 09	.055	
15.46	6.599	6.5443	0 09	.0547	
15.49	6.70	6.644	0 08	.056	
15.53	6.80	6.743	0 08	.057	

TABLE 50.—*Experiment on the development of elastic resistance, &c., of a wire drawn from Lake Superior copper, refined and rolled at the Washington navy-yard*—Continued.

Strain applied 1 foot from center.	Torsion.		Time of application of strain.	Resilience.	Remarks.
	Under strain.	Released.			
Lbs.	*Turns.*	*Turns.*	*m. s.*	*Turns.*	
15. 59	6. 90	6. 8435	0 09	. 0565	
15. 65	7. 00	6. 9435	0 09	. 0565	
15. 72	7. 10	7. 0435	0 09	. 0565	
15. 79	7. 20	7. 1435	0 08	. 0565	
15. 84	7. 30	7. 2437	0 08	. 0563	
15. 88	7. 40	7. 343	0 08	. 057	
15. 92	7. 50	7. 442	0 08	. 058	
16. 00	7. 60	7. 5435	0 08	. 0565	
16. 05	*7. 65	(Broke.)	*0 05	....	

* About.

TABLE 51.—*Experiment on the development of elastic resistance and resilience by torsion. Wire drawn from Martin steel manufactured by the New Jersey Steel and Iron Company.*

[Mark, C J.—Experiment No. 1362.]

Strain applied 1 foot from center.	Torsion.		Time of application of strain.	Resilience.	Remarks.
	Under strain.	Released.			
Lbs.	*Turns.*	*Turns.*	*m. s.*	*Turns.*	
13.63	0.028	0.003	4 45	.015	Length of wire between clamps, 10 inches; form, square; annealed at a temperature between the melting-points of bronze and copper. Measurement of cross-section, 0.2984 x 0.2997; measurement of diagonals before twisting, 0.401 and 0.401; measurement of diagonals after twisting, 0.3985 and 0.3975; contraction in 10 inches of length, 0.050. Annealed at the same time with No. 1353.
14.00	0.028	0.0035	0 20	.0145	
15.00	0.035	0.008	0 10	.027	
16.00	0.052	0.0213	0 15	.0307	
17.00	0.169	0.132	0 57	.037	
18.00	0.2245	0.187	0 30	.0375	
19.00	0.283	0.242	0 25	.041	
20.00	0.337	0.294	0 11	.043	
21.00	0.401	0.355	0 15	.046	
22.00	0.472	0.4238	0 16	.0482	
23.00	0.490	0.489	0 12	.001	
24.00	0.621	0.5679	0 22	.0631	
25.00	0.700	0.644	0 19	.056	
26.00	0.792	0.7335	0 20	.0585	
27.00	0.880	0.8195	0 18	.0605	
28.60	0.993	0.9285	0 20	.0645	
29.00	1.108	1.040	0 23	.068	
30.00	1.238	1.170	0 27	.068	
31.00	1.378	1.3069	0 27	.0711	
32.00	1.526	1.452	0 31	.074	
33.00	1.697	1.6185	0 30	.0785	
34.00	1.879	1.801	0 32	.078	
35.00	2.088	2.0079	0 50	.0801	
36.00	2.337	2.2555	0 40	.0815	
37.00	2.575	2.4919	0 34	.0831	
38.00	2.858	2.3217	0 43	.0863	
39.00	3.140	3.0518	0 39	.0882	
40.00	3.477	3.388	0 45	.089	
41.00	3.818	3.728	0 50	.090	
42.00	4.249	4.157	0 50	.092	
43.00	4.708	4.614	1 03	.094	
44.00	5.229	5.132	1 15	.097	
....	5.367	(Broke.)	0 20	....	Did not raise 45 lbs.; contraction in length, .050.

TABLE 52.—*GUNPOWDER TESTS*

Mark on specimen designating.		Dimensions of original cross-section.	Charge of powder.	Kind of pressure-disk.	Pressure-record on disk.	Pressure indicated—		Elongation—	
Number of experiment.	Material.					Per square inch.	On cross-section of bore.	In 3 inches.	In 1.5 inches.
		Inches.			*Turns.*	*Lbs.*	*Lbs.*	*Inches.*	*Inches.*
1	C Q	.2984 x .2988	1 oz. cannon	....	......	....	....	0.448	....
2	N co I	.2895 x .2925	....do	....	......	....	....	1.014	....
3	C H co 4 S	.2915 x .2975	....do	....	......	....	....	0.360	....
4	B B	.3011 x .3012	....do	....	......	....	....	....	0.225
5	B B	.3011 x .3012	1.5 oz. cannon.	Copper	2.60	7,680	28,247	....	0.336
6	B B	.3011 x .3012	...do	...do	2.60	7,680	28,247	0.635	....
7	A co 2	.2972 x .2992	1 oz. cannon	Zinc and tin.	1.70	1,788	6,576	0.537	.242 and .295
8	A co 5	.2995 x .2981	1 oz. musket	...do	1.60	1,710	6,289	0.682	.349 and .333
9	C K	.2978 x .2990	....do	...do	1.85	2,040	7,503	0.550	.315 and .235
10	C S co 5	.295 x .297	....do	Tin	3.00	1,032	3,796	0.316	.162 and .154
11	C S co 9 *	.3014 x .3022	....do	...do	3.00	1,032	3,796	0.264	.155 and .109
12	H W co 4	.305 x .295	....do	...do	2.98	1,026	3,774	0.350	.175 and .175
13	T co 3 *	.2995 x .301	....do	...do	2.75	906	3,332	0.437	.216 and .221
14	T co 6 *	.300 x .3007	....do	...do	3.18	1,116	4,105	0.218	.107 and .111
15	C L	.2978 x .2989	....do	...do	2.58	834	3,067	0.999	.492 and .507
16	(Hard-drawn copper.)	.2953 x .2957	....do	...do	2.20	648	2,383	0.267	.200 and .067
17	A co 56 *	.297 x .296	....do	...do	2.90	990	3,641	....	.341
18	A co 76 *	.2962 x .2965	....do	...do	2.62	858	3,156	.6160	.3125 and .3045
19	B F	.3028 x .3025	....do	...do	2.80	936	3,443	.778	.366 and .412
20	B M	.3036 x .3043	....do	...do	3.09	1,068	3,928	.161	.082 and .079
21	B S co * 5	.2989 x .2988	....do	...do	2.23	678	2,494	....	.513+
22	C R	.302 x .299	....do	...do	2.60	846	3,111	....	.321

compared with tensile and torsional tests.

Measurements of cross-section at fracture or smallest place.	Elongation by action of gunpowder.	Reduction of area of cross-section by action of gunpowder.	Elongation in tensile-testing machine.	Reduction of area of cross-section in tensile-testing machine.	Highest strain on similar specimen in tensile-testing machine.	Breaking torsional strain, applied 1 foot from center.	Ultimate torsion, specimen 1 inch long.	Remarks.
Inches.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Lbs.*	*Lbs.*		
.240 x .240	14. 91	47. 93	....	....	....	48. 45	0. 594	Broke outside the marks, near an outer one.
.147 x .137	33. 76	76. 41	28. 56	59. 58	4, 050	30. 74	1. 116	Broke outside the marks.
.274 x .2755	11. 98	15. 91	14. 14	36. 39	8, 300	50. 14	. 751	Was not parted.
....	15. 00	....	14. 68	24. 95	8, 300	53. 87	. 761	Broke between marks.
....	21. 86	....	....	....	....	55. 87	. 785	Do.
....	21. 14	....	....	....	....	56. 40	. 759	Broke outside the marks.
.2698 x .270	17. 88	16. 78	12. 18	35. 30	7, 950	52. 87	. 712	Was not parted.
.245 x .244	22. 71	31. 20	12. 16	34. 47	8, 190	53. 91	. 722	Broke within the marks, near an outer one.
.256 x .257	18. 31	24. 89	12. 35	35. 06	8, 100	55. 81	. 789	Did not part.
.277 x .2795	10. 52	11. 76	9. 05	40. 67	7, 800	50. 54	. 589	Broke ; extended evenly.
.285 x .290	8. 79	15. 05	....	....	....	61. 45	. 373	Did not break.
.276 x .277	11. 65	16. 40	5. 83	44. 73	8, 300	57. 26	. 730	Do.
.236 x .238	14. 55	37. 67	10. 06	38. 56	8, 380	50. 70	. 472	Broke.
.289 x .292	7. 25	6, 67	....	....	....	65. 99	. 2765	Did not break; stretched evenly.
.207 x .208	33. 30	51. 63	....	....	....	40. 98	1. 157	Broke.
.192 x .192	8. 89	57. 46	....	....	....	21. 01	. 929	Broke; little extension except near place of fracture
.206 x .208	....	51. 31	....	....	....	46. 46	. 691	Broke within the marks, near an outer one.
.220 x .222	20. 51	44. 54	16. 18	42. 87	7, 340	47. 69	. 686	Broke in two places, outside the marks, near the outer ones.
.195 x .195	25. 90	58. 55	19. 42	39. 71	7, 500	45. 41	. 906	Broke outside the marks.
.2935 x .295	5. 36	6. 19	8. 92	18. 87	10, 180	63. 79	. 658	Not broken.
.192 x .192	34. 20	58. 70	....	....	....	44. 86	. 860	Broke near the central mark
.194 x .195	21. 40	59. 34	....	....	....	41. 05	. 759	Broke within the marks.

TABLE 53.—*Comparison of chemical with mechanical tests.*

Mark designating kind of wire.	Chemical tests.						Mechanical tests.						
							Torsional.				Tensile.		
	Numbers.	Carbon.	Silicon.	Manganese.	Sulphur.	Phosphorus.	Numbers.	Average yielding-strain applied 1 foot from center.	Average breaking-strain applied 1 foot from center.	Average ultimate torsion in turns per inch of length.	Numbers.	Breaking strain, (lbs. per square inch of original section.)	Reduction of area of section at place of fracture.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent*	*Per cent.*		*Lbs.*	*Lbs.*			*Lbs.*	*Per cent.*
O (C H co)	1	0. 399	0. 019	0. 324	0. 045	0. 137	86	....	....	1. 3335	90	56, 450	56. 34
H W co 4	2	0. 726	0. 150	0. 359	0. 028	0. 039	215, 216	17. 16	57. 41	0. 730	54, 55	105, 200	40. 40
T co 3	3	0. 644	0. 154	0. 346	0. 019	0. 025	400, 411	17. 98	55. 83	0. 413	156, 157	93, 500	17. 80
D M (H W co)	4	0. 720	0. 093	0. 323	0. 024	0. 042	353, 375	15. 68	54. 21	0. 591	....	....	....
C H co 4 S	5	0. 682	0. 070	0. 847	0. 044	0. 109	177, 178	15. 00	52. 00	0. 833	10	95, 700	36. 59

[ADDENDUM NOT TRANSMITTED WITH REPORT.]

TABLE No. 54.—*TORSIONAL TESTS.—Experiments relating to the effect of the continuance of strain on the extent of torsion.*

[For explanation of marks, see page 136.]

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Time of application of strain.	Resilience.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0″.3 x 0″.3.	Remarks.
Material.	No. of experiment.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns*	*h. m. s.*	*Turns.*	*Inches.*	*Lbs.*	
B B...........	481	15.70	.01	.003	1 58	.007	.3018 x .305	15.17	Specimens numbered 481, 482, 483, 484, and 485 were annealed together, at standard heat. The times in which strains were applied in these five experiments were intended to correspond very nearly with each other. Tests for variability of specimens of the same steel.
		50.45	.409	.480	2 38	.019	....	48.77	
		54.05	.7345	(Broke.)	0 29	....	....	52.25	
B B...........	482	15.50	.01	.0035	1 35	.0065	.301 x .3015	15.30	
		49.95	.500	.482	2 39	.018	....	49.33	
		54.19	.7985	(Broke.)	0 28	....	....	53.51	
B B...........	483	15.75	.01	.0035	1 30	.0065	.3022 x .3013	15.47	
		50.34	.508	.469	2 50	.019	....	49.47	
		53.86	.771	(Broke.)	0 33	....	....	52.93	
B B...........	484	14.85	.01	.0035	1 30	.0065	.3013 x .301	14.68	
		48.84	.501	.483	2 12	.018	....	48.28	
		53.15	.7775	(Broke.)	0 33	....	....	52.54	
B B...........	485	15.10	.01	.0035	2 10	.0065	.301 x .301	14.95	
		49.38	.502	.4835	2 40	.0185	....	48.90	
		53.38	.763	(Broke.)	0 25	....	....	52.87	
B B...........	524	50.00	Not taken	.537	0 50	....	.3023 x .3029	48.75	50 pounds strain applied in 50 seconds, and immediately released, without reading "torsion under strain."
		50.00	.568	....	0 5	....	....	....	50 pounds re-applied rapidly.
		Do. continued	.649	.630+	6 10	.019+	....	....	Torsion nearly ceased at the end of 6 minutes 10 seconds.
		(55—?)	.820	(Broke.)	0 27	....	....	*53.62	Weights set for strain of 55 pounds, which was not reached.
B B...........	525	(55—?)	.840	(Broke.)	1 5	....	.3022 x .302	*53.86	Do.
B B...........	526	(55—?)	.855	(Broke.)	0 50	....	.3016 x .3017	*54.08	Strain of 55 pounds not reached.

* Less than.

TABLE NO. 54.—*TORSIONAL TESTS.—Experiments relating to the effect of the continuance of strain on the extent of torsion*—Continued.

Mark on specimen designating—		Strain applied 1 foot from center.	Torsion.		Time of application of strain.	Resilience.	Measurement of cross-section.	Strain reduced to correspond to cross-section of 0″.3 x 0″.3.	Remarks.
Material.	No. of experiment.		Under strain.	Released.					
		Lbs.	*Turns.*	*Turns.*	*h. m. s.*	*Turns.*	*Inches.*	*Lbs.*	
B B	574	53.92	.7805	(Broke.)	1 13	....	.3025 x .3021	....	
B B	529	40.00	.211	.198	0 17	.013	.3014 x .3016	39.40	40 pounds raised in 17 seconds, and strain immediately released; resilience .013.
		Continued	.238	....	1 0	....	....	39.40	
		Do	.2415	....	1 0	....	....	39.40	
		Do	.2435	....	1 0	....	....	39.40	[Specimens B B numbered 524, 525, 526, 574, and 529 were annealed together at standard heat.]
		Do	.2450	....	1 0	....	....	39.40	
		Do	.2467	....	1 0	....	....	39.40	
		Do	.2473	....	1 0	....	....	39.40	
		Do	.2483	....	1 0	....	....	39.40	
		Do	.2487	....	1 0	....	....	39.40	
		Do	.2489	....	1 0	....	....	39.40	
		Do	.2495	....	1 0	....	....	39.40	
		Do	.2498	....	1 0	....	....	39.40	
		Do	.2504	....	1 0	....	....	39.40	
		Do	.251	....	1 0	....	....	39.40	
		Do	.2512	....	1 0	....	....	39.40	
		Do	.2514	....	1 0	....	....	39.40	
		Do	.2516	....	1 0	....	....	39.40	
		Do	.2519	....	1 0	....	....	39.40	
		Do	.2522	....	1 0	....	....	39.40	
		Do	.2524	....	1 0	....	....	39.40	
		Do	.2529	....	1 0	....	....	39.40	
		Do	.2533	....	1 0	....	....	39.40	
		Do	.2535	.2384	1 11	.0151	....	39.40	At the end of 23 minutes 28 seconds the strain was released. The previous strain (40 pounds) was re-applied carefully, requiring 1 minute 30 seconds. Torsion under strain, .257. The lever settled to touch support (equivalent to an additional torsion of .0015) in 7½ minutes. Strain was left on from 11:57 of April 7 to 11 a. m. of the 8th—23 hours 3 minutes. Lever balanced on reducing strain to 29.65 pounds. Torsion released, .2448.
		40.00	.257	....	1 30	....	....	....	
		Continued	.2585	....	7 30	....	....	....	
		Varying from 40.00 to 29.65.	.257	.2448	23 3 0	.0122	....	....	
		35.65	.257	....	0 2	....	....	35.11	Strain brought to 35.65 pounds in 2 seconds. After standing 5 minutes the lever had not fallen any.
		Continued	.257	....	5 0	....	....	35.11	

		40. 00	. 260	....	0	5	....	....	39. 40	40 pounds re-applied. Lever settled to touch in 2 minutes 5 seconds; stood in that way 1 minute 55 seconds, when lever was raised to central line in 2 seconds, torsion being .262.
		Continued	. 2815	....	2	5	....	....	39. 40	
		Do.........	. 262	....	1	57	....	....	....	
		Do.........	. 2635	....	17	0	....	....	39. 40	Lever settled to touch in 17 minutes; stood in this way 4 minutes.
		(40. 00 to ?)	....	....	4	0	....	....	....	After standing with lever touching 4 minutes, torsion was recommenced, increasing the strain in the usual way to keep lever at center. Broke with strain of 53.04 pounds, reached in 3 minutes 32 seconds.
		53. 04	. 828	(Broke.)	3	32	....	....	52. 25	

TESTS OF HARDNESS.

In order that the comparisons of the several kinds of steel, in respect to hardness, should be freed from liability to error as far as practicable, a set of specimens (short pieces of gun-wires) was prepared by annealing them together at the standard heat.

They were tested in the Rodman machine, at the Washington navy-yard, the adjustment of the apparatus remaining the same throughout the experiments.

The test applied consisted in determining the extent of the indentations made in the several specimens by a pyramidal indenting-tool resembling the "cutter" of the Rodman pressure-gauge, under a uniform pressure of two thousand pounds. The proportions of the indenting-tool are such that the base of the pyramid is a rhomb, having its diagonals as one to seven in length, and its height about one-half the length of the shorter diagonal; or the relation of its dimensions may be more exactly stated as follows: Long diagonal, 607; short diagonal, 87; height, 42.

After the indentations were made the pieces were carefully examined, and a few rejected on account of imperfections not visible before the experiment. When slight imperfections, not supposed to have material influence on the results, were found, the experiments are included in the table, with the proper remark. In none of these cases was any defect in the metal discovered where the indentation was made. The result of the imperfections, if any, would of course be to *lengthen* the cut.

The indenting-tool appears not to have suffered any change from use.

TABLE 55.—*TESTS OF HARDNESS, (Resistance to indentation.)*

[For explanation of marks, see pages 136 to 140.]

Mark designating material.	Length of cut under pressure of 2,000 pounds.	Remarks.
	Inches.	
H W co 4	0.272	
H W co 5	0.370	
H W co 7	0.326	
H W co 8	0.250	
H W co 9	0.283	
H W co 13	0.313	
H W co 14	0.315	
H W co 16	0.329	Slight widening of surface on which indentation is made, detected.
H W co 17	0.300	
H W co 18	0.310	
H W co 19	0.314	
H W co 20	0.292	
H W co T	0.249	
C H co 1	0.331	Slight widening of surface detected.
C H co 2	0.334	
C H co 3	0.332	
C H co 4	0.278	
C H co 5 I	0.369	
C H co 6	0.326	Specimen not perfect.
C H co 7	0.340	Imperfection on opposite side.
C H co 9	0.345	
C H co (E F)	0.308	
C H co Spr G 1.1	0.360	
C H co Spr G 3.2	0.376	
S P R 1	0.287	Imperfection at one corner. Probably has *no* effect.
S P R 2	0.276	
S P R 3	0.276	
S P R 4	0.254	
S P R 5	0.272	
S P R 6	0.285	
S P R 7	0.302	

TABLE 55.—*TESTS OF HARDNESS, &c.*—Continued.

Mark designating material.	Length of cut under pressure of 2,000 pounds.	Remarks.
	Inches.	
S P R 8	0. 306	
S P R 10	0. 307	
S P R 11	0. 306	
S P R 12	0. 311	
S P R 13	0. 289	
S P R 14	0. 286	
S P R 15	0. 288	
S P R 16	0. 282	
S P R 17	0. 278	
S P R 18	0. 294	
S P R 21	0. 285	
S P R 22	0. 279	
S P R 25	0. 279	Not perfect in plane transverse to cut.
S P R 27	0. 270	
S P R 29	0. 277	
S P R 31	0. 307	
S P R 32	0. 301	
S P R 36	0. 345	
S P R 37	0. 329	
S P R 38	0. 327	
S P R 39	0. 318	
S P R 40	0. 307	
S P R 41	0. 320	
S P R 42	0. 287	
S P R 43	0. 302	
S P R 45	0. 360	
S P R 46	0. 280	Slight widening of surface.
S P R 47	0. 284	
S P R 48	0. 294	Slight imperfection on the same side with indentation; supposed not to affect it.
S P R 49	0. 311	
S P R 50	0. 299	
S P R 51	0. 307	
S P R 52	0. 306	
S P R 53	0. 320	
S P R 54	0. 307	
S P R 55	0. 308	
S P R 56	0. 306	
S P R 57	0. 330	
S P R 58	0. 301	
S P R 60	0. 310	
S P R 61	0. 306	Imperfect in plane transverse to cut.
S P R 62	0. 300	
S P R 63	0. 302	
S P R 64	0. 331	
S P R 65	0. 312	
S P R 66	0. 316	
S P R 67	0. 305	
S P R 68	0. 304	
S P R 69	0. 312	
S P R 70	0. 308	
S P R 71	0. 310	
C S co 5	0. 285	Slight widening of surface. Cut not central.
C S co 6	0. 296	
C S co 7	0. 331	
C S co 8	0. 294	
C S co 9	0. 253	
C S co 10	0. 248	
C S co 11	0. 285	
C S co 12	0. 268	
C S co 13	0. 273	
C S co 14	0. 262	
C S co 15	0. 262	
C S co 16	0. 263	
C S co 17	0. 262	
C S co 18	0. 264	
P B co 1	0. 351	
P B co 2	0. 316	
P B co 3	0. 333	
P B co 4	0. 305	
M co 1	0. 327	
M co 2	0. 300	
M co 3	0. 244	
M co 4	0. 308	
M co 5	0. 366	Surface slightly widened.

TABLE 55.—*TESTS OF HARDNESS, &c.*—Continued.

Mark designating material.	Length of cut under pressure of 2,000 pounds.	Remarks.
	Inches.	
T co 1	0. 247	
T co 2	0. 257	
T co 3	0. 271	
T co 6	0. 258	
T co 8	0. 263	
T co 9	0. 250	
T co 10	0. 248	
T co 11	0. 255	
T co 13	0. 244	
T co 14	0. 251	
T co 15	0. 255	
T co 16	0. 262	
N S co 1	0. 329	
N S co 2	0. 307	
N S co 3	0. 330	
N S co 4	0. 340	Slight widening of surface.
N S co 5	0. 345	
N S co 6	0. 237	
N S co 7	0. 270	
N S co 8	0. 310	
N S co 9	0. 293	
N S co 10	0. 288	
N S co 11	0. 299	
N S co 12	0. 287	
C co 1	0. 273	
C co 2	0. 288	
C co 5	0. 280	
C co 6	0. 281	
C co 7	0. 282	
C co 8	0. 288	
C co 9	0. 288	
C co 16	0. 268	
C co 17	0. 289	
C co 18	0. 305	
C co 20	0. 278	
B	0. 331	
C	0. 345	
D	0. 345	
E	0. 350	
F	0. 339	
G	0. 310	
H	0. 323	
I	0. 355	Surface widened slightly.
J	0. 316	
K	0. 337	
L	0. 318	
M	0. 339	
N	0. 345	Slight widening of surface.
O	0. 333	
P	0. 348	
Q	0. 341	
R	0. 342	
S	0. 327	
T	0. 312	
U	0. 334	
V	0. 324	
W	0. 341	
X	0. 342	
Y	0. 339	
Z	0. 319	
A A	0. 347	
A B	0. 324	
A C	0. 307	
A D	0. 322	
A E	0. 345	
A F	0. 328	
A G	0. 329	
A H	0. 345	Surface slightly widened.
A I	0. 323	
A J	0. 338	
A K	0. 338	
A L	0. 325	
A M	0. 337	

TABLE 55.—*TESTS OF HARDNESS, &c.*—Continued.

Mark designating material.	Length of cut under pressure of 2,000 pounds.	Remarks.
	Inches.	
A N	0.326	
A O	0.346	
A P	0.347	
C F	0.315	
C H	0.308	
C J	0.307	
C K	0.286	
B B	0.283	
B N	0.279	Separately annealed; standard heat.
B R	0.283	
A co 1	0.297	
A co 2	0.283	
A co 3	0.290	
A co 4	0.308	
A co 6	0.281	
A co 8	0.320	Slight imperfection.
A co 10	0.292	
A co 11	0.257	
A co 12	0.269	
A co 13	0.265	
A co 15	0.283	
A co 17	0.280	
A co 18	0.275	
A co 19	0.292	
A co 20	0.260	
A co 21	0.275	
A co 22	0.249	
A co 23	0.299	
A co 24	0.287	
A co 25	0.307	
A co 26	0.309	
A co 28	0.301	
A co 30	0.289	
A co 31	0.294	
A co 32	0.281	
A co 34	0.257	
A co 35	0.256	
A co 38	0.269	
A co 39	0.252	
A co 40	0.247	
A co 43	0.302	
A co 44	0.313	
A co 47	0.274	
A co 48	0.302	
A co 50	0.281	
A co 51	0.299	
A co 52	0.313	
A co 57	0.288	
A co 58	0.304	
A co 59	0.284	
A co 61	0.293	
A co 64	0.296	
A co 65	0.278	
A co 66	0.287	
A co 67	0.284	
A co 68	0.285	
A co 69	0.307	
A co 70	0.296	
A co 71	0.280	
A co 72	0.303	
A co 73	0.266	
A co 74	0.300	
A co 75	0.288	
A co 76	0.300	
A co 77	0.298	
A co 78	0.288	
A co 79	0.297	
A co 80	0.289	
A co 81	0.272	
A co 86	0.252	
A co 87	0.257	
A co 88	0.252	
A co 89	0.266	

TABLE 55.—*TESTS OF HARDNESS, &c.*—Continued.

Mark designating material.	Length of cut under pressure of 2,000 pounds.	Remarks.
	Inches.	
A co 90	0. 252	
A co 91	0. 282	
A co 92	0. 242	
A co 93	0. 263	
A co 94	0. 248	
A co 95	0. 255	
A co 96	0. 273	
A co 97	0. 285	
A co 98	0. 281	
A co 99	0. 280	
A co 100	0. 284	
A co 102	0. 274	
A co 104	0. 265	
A co 105	0. 279	
A co 106	0. 277	
A co 107	0. 282	
A co 109	0. 268	
A co 110	0. 277	
A co 112	0. 275	
A co 114	0. 278	
A co 115	0. 265	
A co 129	0. 294	
A co 130	0. 291	
A co 132	0. 295	
A co 135	0. 298	
A co 136	0. 300	
A co 137	0. 291	
A co 138	0. 306	
A co 139	0. 283	
A co 140	0. 275	
A co 141	0. 264	
A co 142	0. 281	
A co 143	0. 270	
A co 144	0. 311	
A co 145	0. 273	
A co 146	0. 293	
A co 147	0. 274	
Bes 3	0. 289	
Bes 4	0. 286	
Bes 16	0. 269	
H co 1	0. 287	
H co 2	0. 288	
J co 1	0. 284	
J co 2	0. 294	
J B H co	0. 285	
E M co 1	0. 265	
E M co 2	0. 278	
H E co 1	0. 277	
H E co 2	0. 260	
N co 1 S (c)	0. 298	
N co 1 T	0. 266	
N co 2 T	0. 265	
S B co 1	0. 269	
S B co 2	0. 286	
12″ B	0. 349	

Plate. 1.

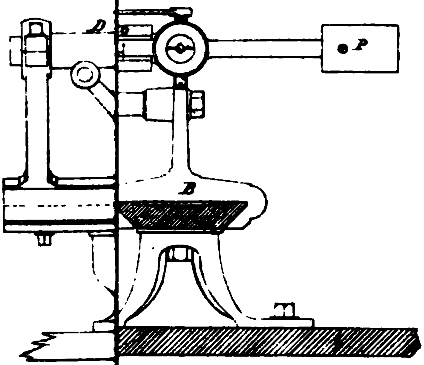
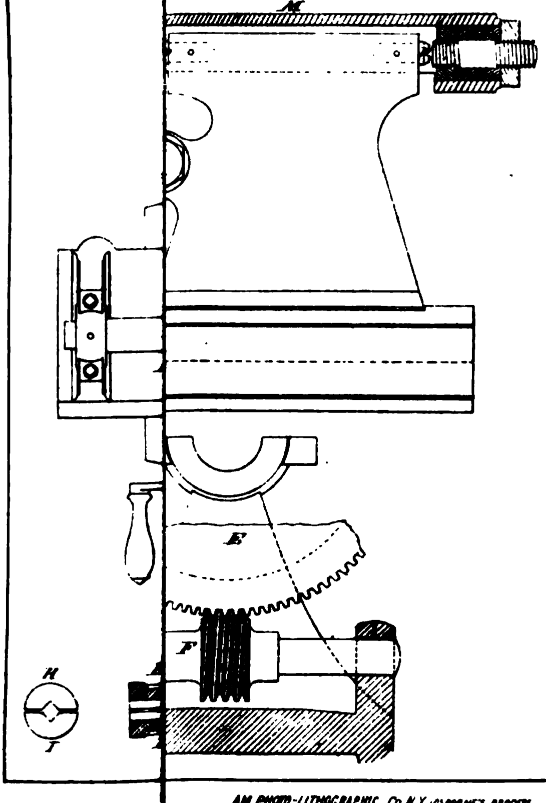


Fig. 6

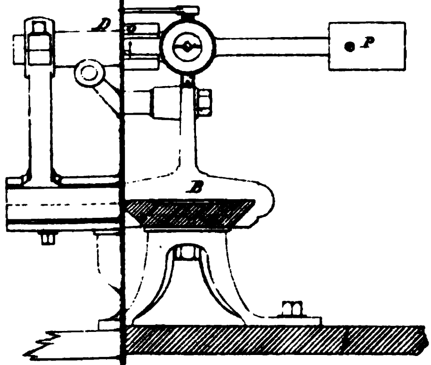


AM PHOTO-LITHOGRAPHIC Co N.Y. (OSBORNE'S PROCESS)

TABLE 55.—*TESTS OF HARDNESS, &c.*—Continued.

Mark designating material.	Length of cut under pressure of 2,000 pounds.	Remarks.
	Inches.	
A co 90	0. 252	
A co 91	0. 282	
A co 92	0. 242	
A co 93	0. 263	
A co 94	0. 248	
A co 95	0. 255	
A co 96	0. 273	
A co 97	0. 285	
A co 98	0. 281	
A co 99	0. 280	
A co 100	0. 284	
A co 102	0. 274	
A co 104	0. 265	
A co 105	0. 279	
A co 106	0. 277	
A co 107	0. 282	
A co 109	0. 268	
A co 110	0. 277	
A co 112	0. 275	
A co 114	0. 278	
A co 115	0. 265	
A co 129	0. 294	
A co 130	0. 291	
A co 132	0. 295	
A co 135	0. 298	
A co 136	0. 300	
A co 137	0. 291	
A co 138	0. 306	
A co 139	0. 283	
A co 140	0. 275	
A co 141	0. 264	
A co 142	0. 281	
A co 143	0. 270	
A co 144	0. 311	
A co 145	0. 273	
A co 146	0. 293	
A co 147	0. 274	
Bes 3	0. 289	
Bes 4	0. 286	
Bes 16	0. 269	
H co 1	0. 227	
H co 2	0. 288	
J co 1	0. 284	
J co 2	0. 294	
J B H co	0. 285	
E M co 1	0. 265	
E M co 2	0. 278	
H E co 1	0. 277	
H E co 2	0. 260	
N co 1 S (c)	0. 298	
N co 1 T	0. 266	
N co 2 T	0. 265	
S B co 1	0. 269	
S B co 2	0. 286	
12″ B	0. 349	

Plate. 1.



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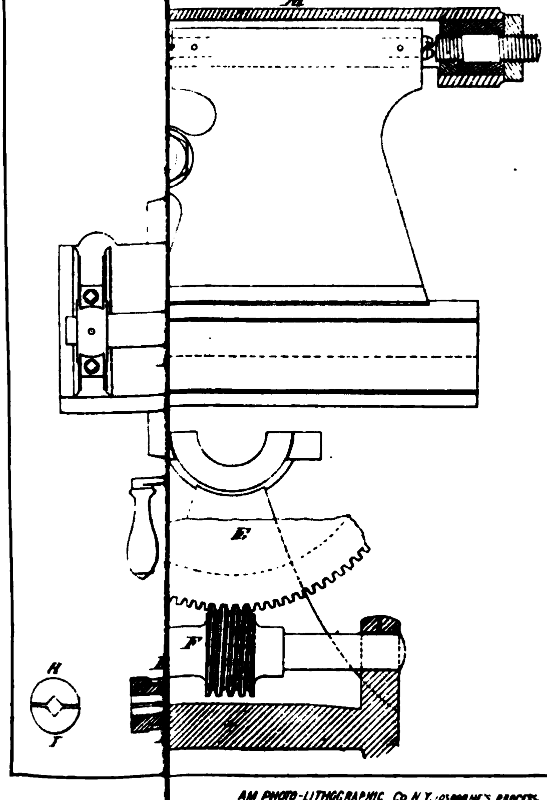


AM. PHOTO-LITHOGRAPHIC Co N.Y. (OSBORNE'S PROCESS.

Plate 2

Fig. 1

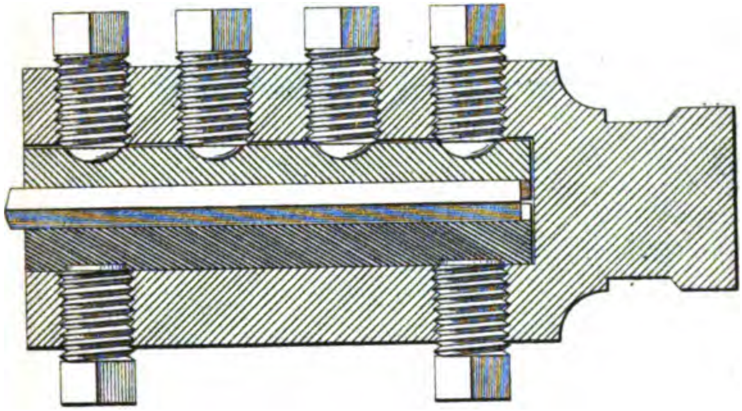
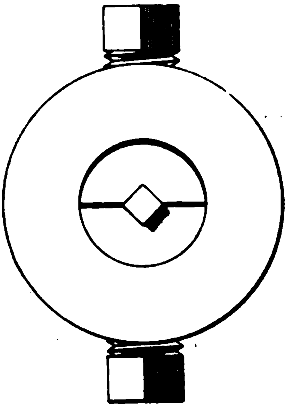


Fig. 2



AM. PHOTO-LITHOGRAPHIC Co. N.Y. (OSBORNE'S PROCESS)

Plate. 3

Fig. 1

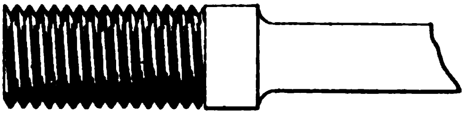


Fig. 2

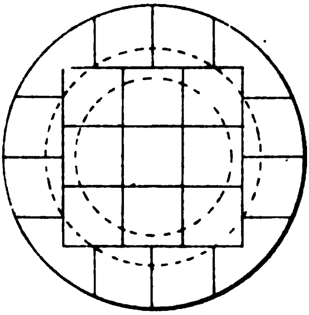


Fig. 3

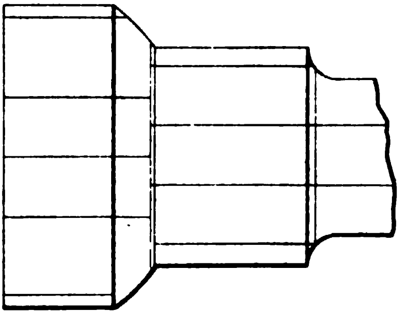
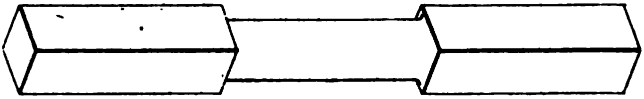


Fig. 4

Fig. 5



AM. PHOTO-LITHOGRAPHIC Co. N.Y. (OSBORNE'S PROCESS)

Plate. 4

Fig. 1

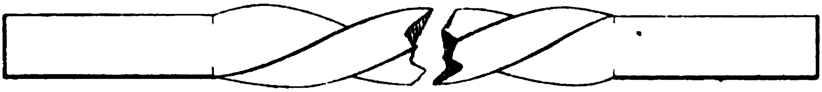


Fig. 2

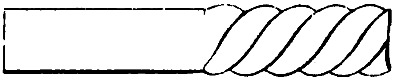


Fig. 3

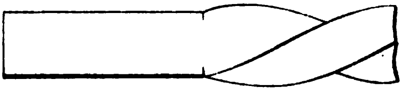


Fig. 4

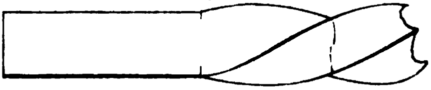


Fig. 5

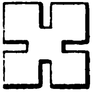


Fig. 6

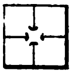


Fig. 7

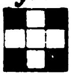
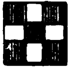


Fig. 8



AM. PHOTO-LITHOGRAPHIC Co. N.Y. (OSBORNE'S PROCESS)

Plate. 5

Fig. 1

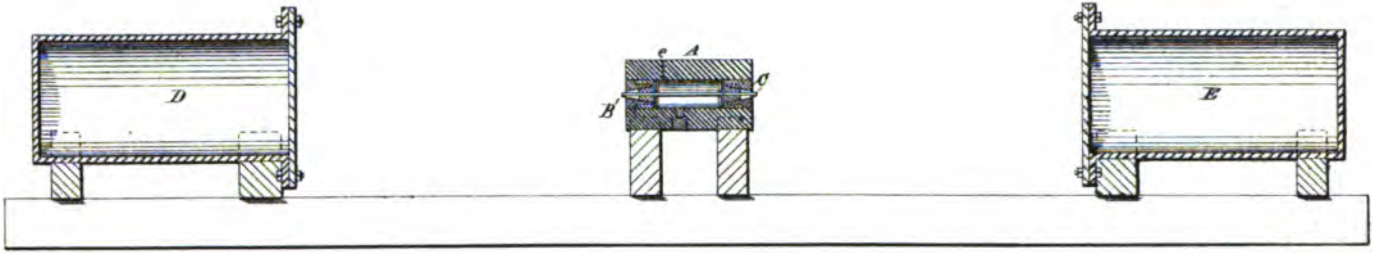


Fig. 4

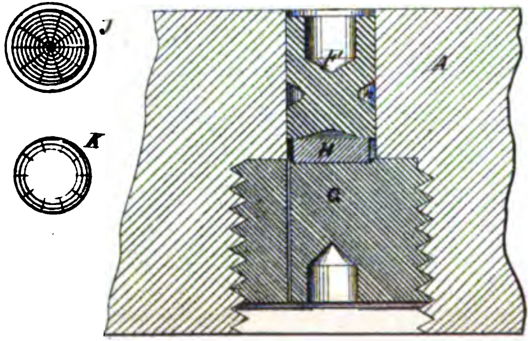


Fig. 2

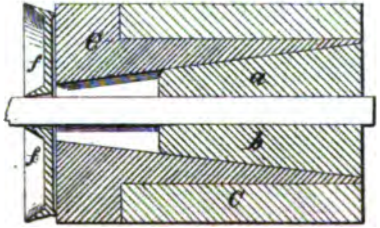
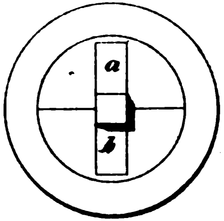
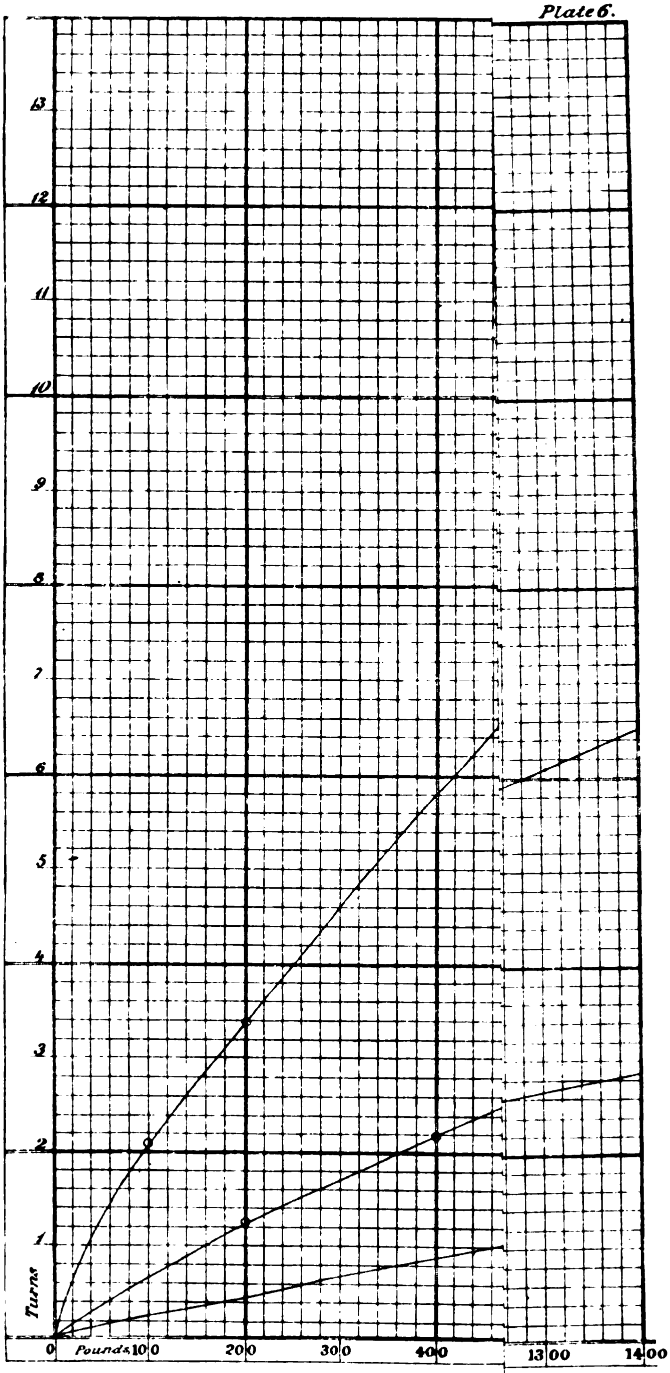


Fig. 3



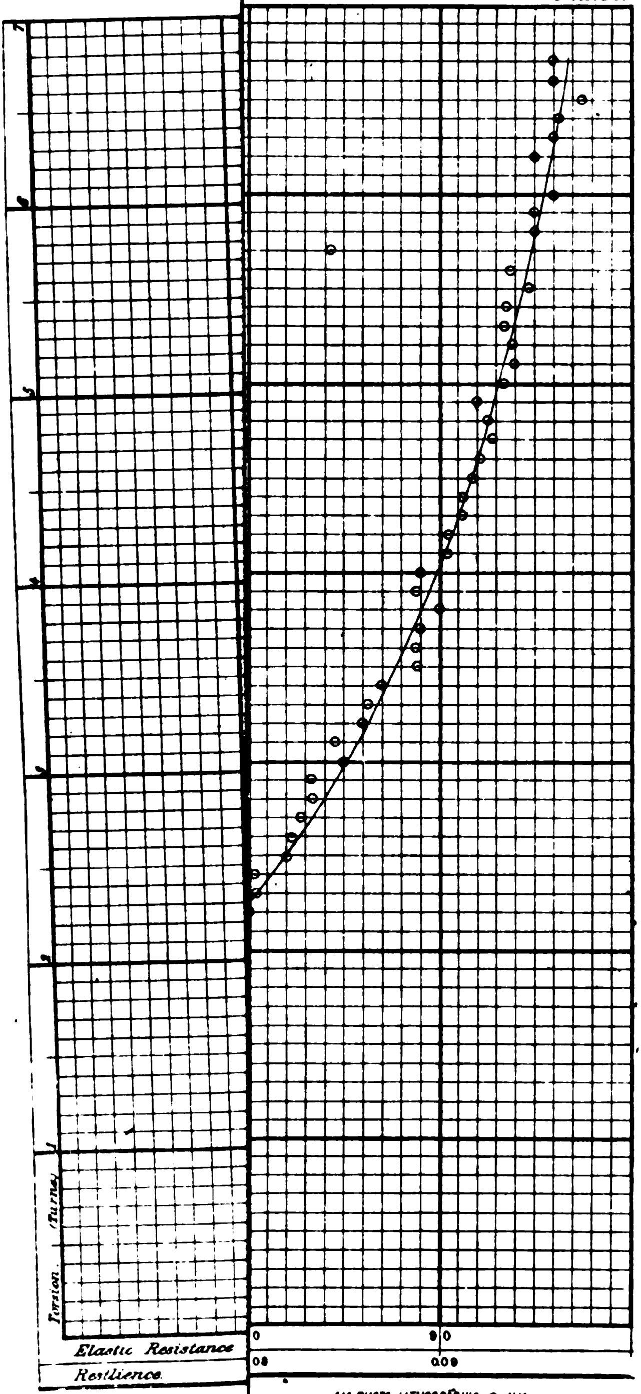
AM PHOTO-LITHOGRAPHIC Co. N.Y. (OSBORNE'S PROCESS)

Plate 6.



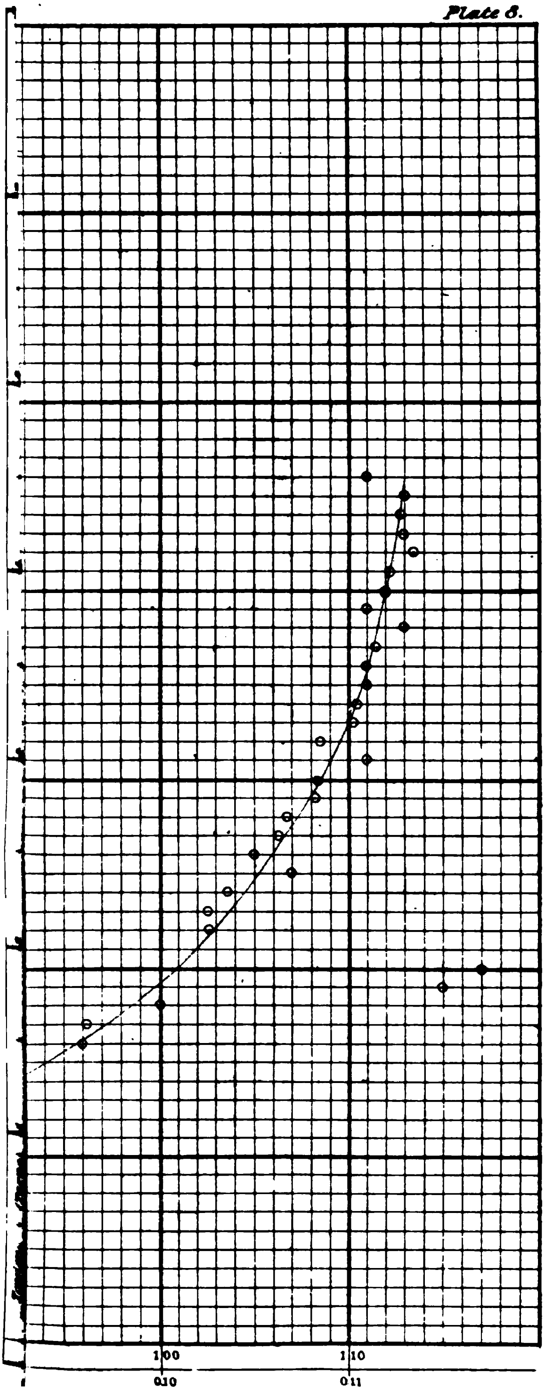
N.Y. (OSBORNE'S PROCESS)

Plate 7.



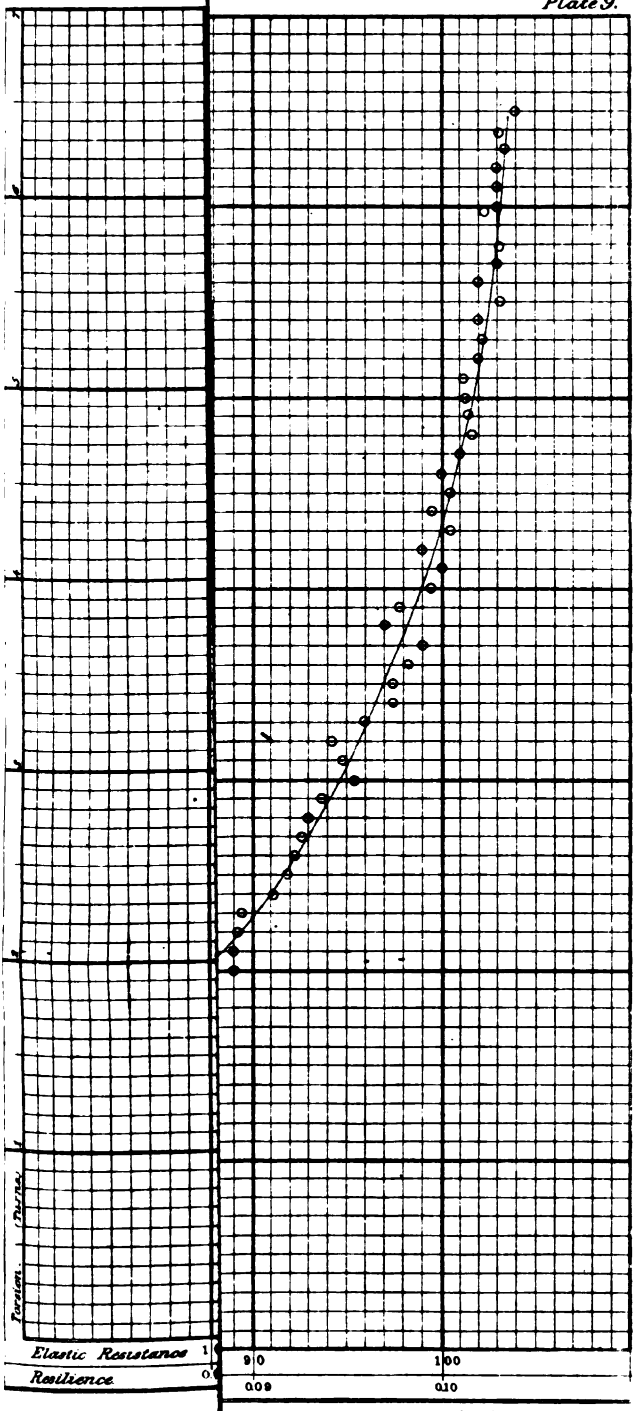
AM. PHOTO LITHOGRAPHIC Co. N.Y. (OSBORNE'S PROCESS)

Plate 8.



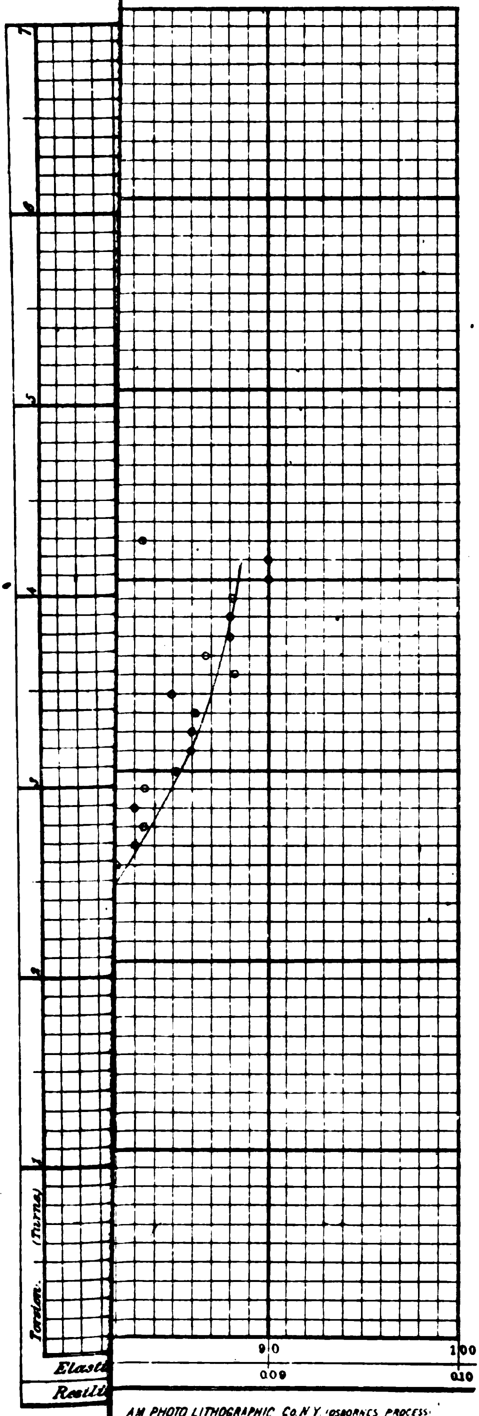
AM. PHOTO-LITHOGRAPHIC Co. N.Y. (OSBORNE'S PROCESS.)

Plate 9.



AM PHOTO-LITHOGRAPHIC CO N.Y. (OSBORNE'S PROCESS.)

Plate 10



AM. PHOTO LITHOGRAPHIC Co. N.Y. (OSBORNE'S PROCESS)

Plate 11.

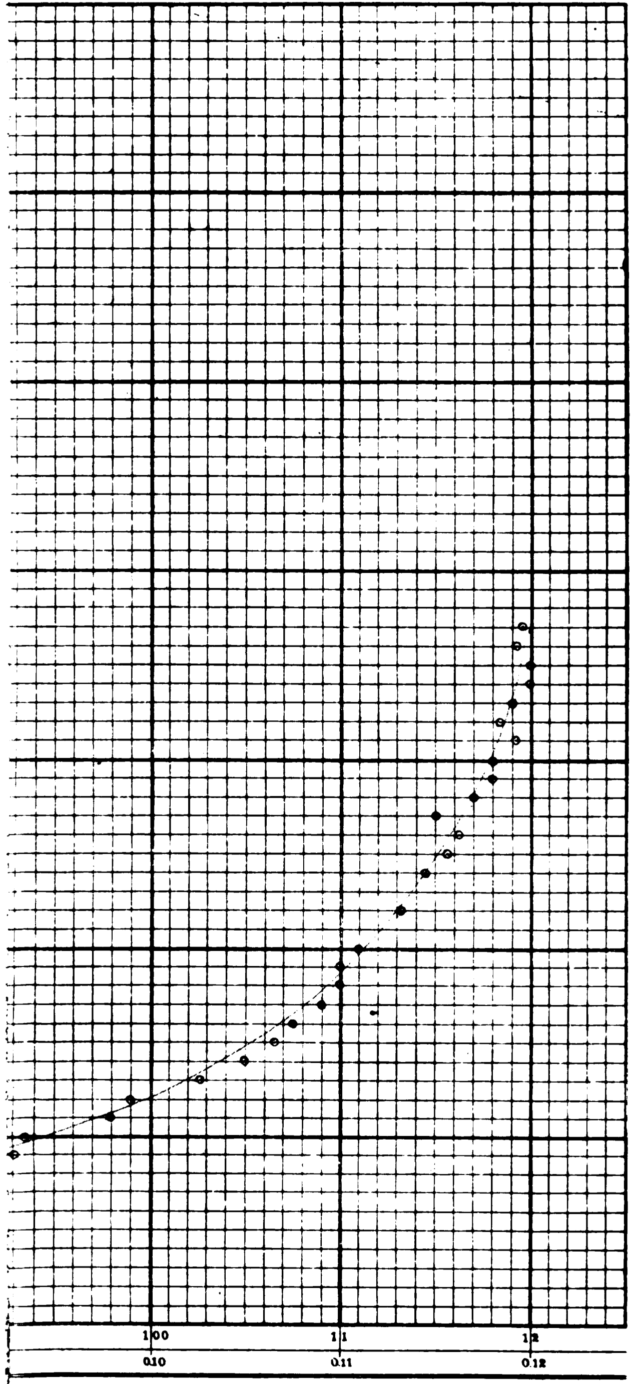
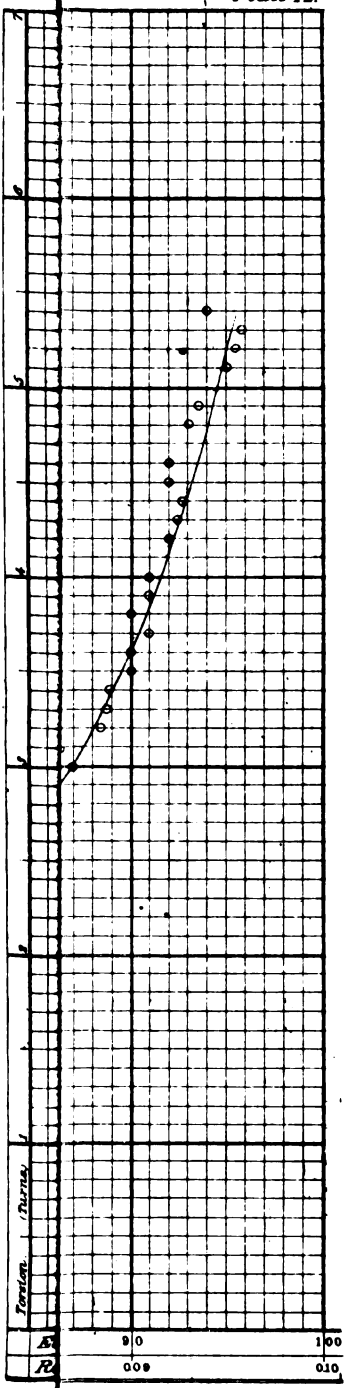
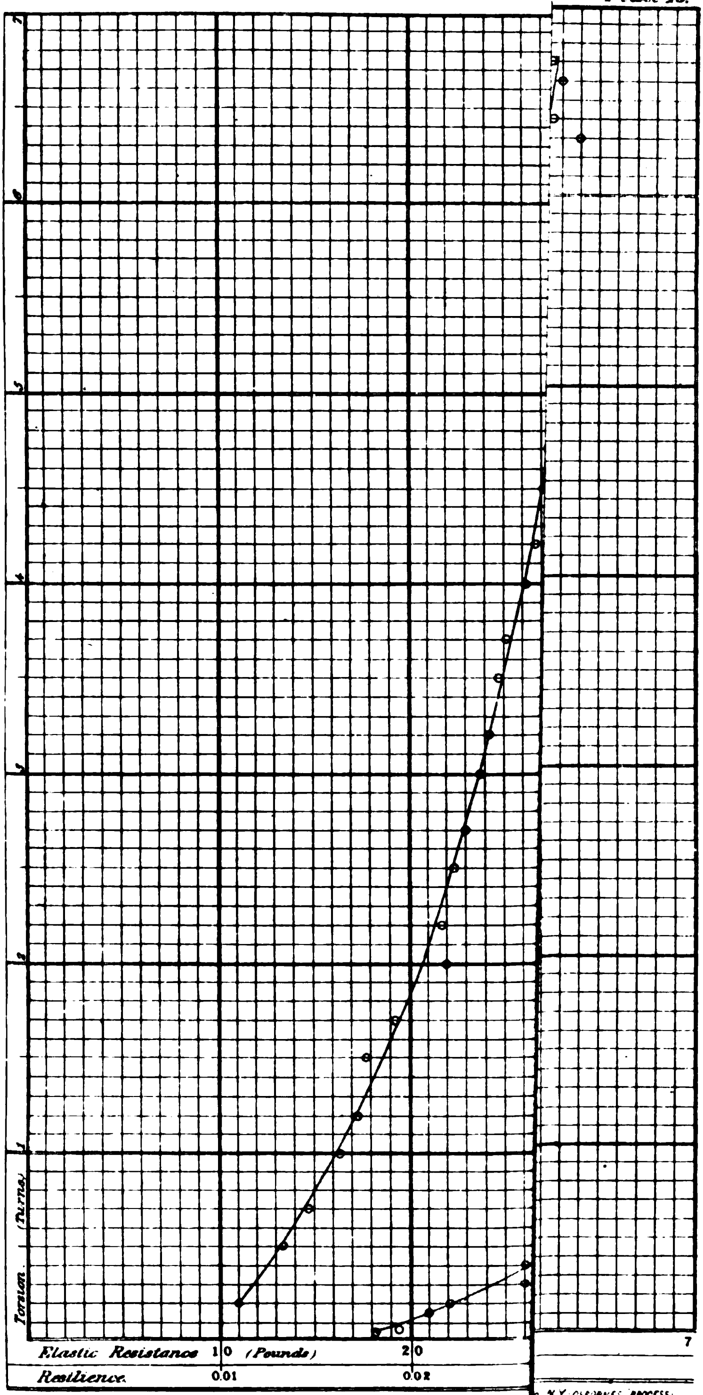


Plate 12.



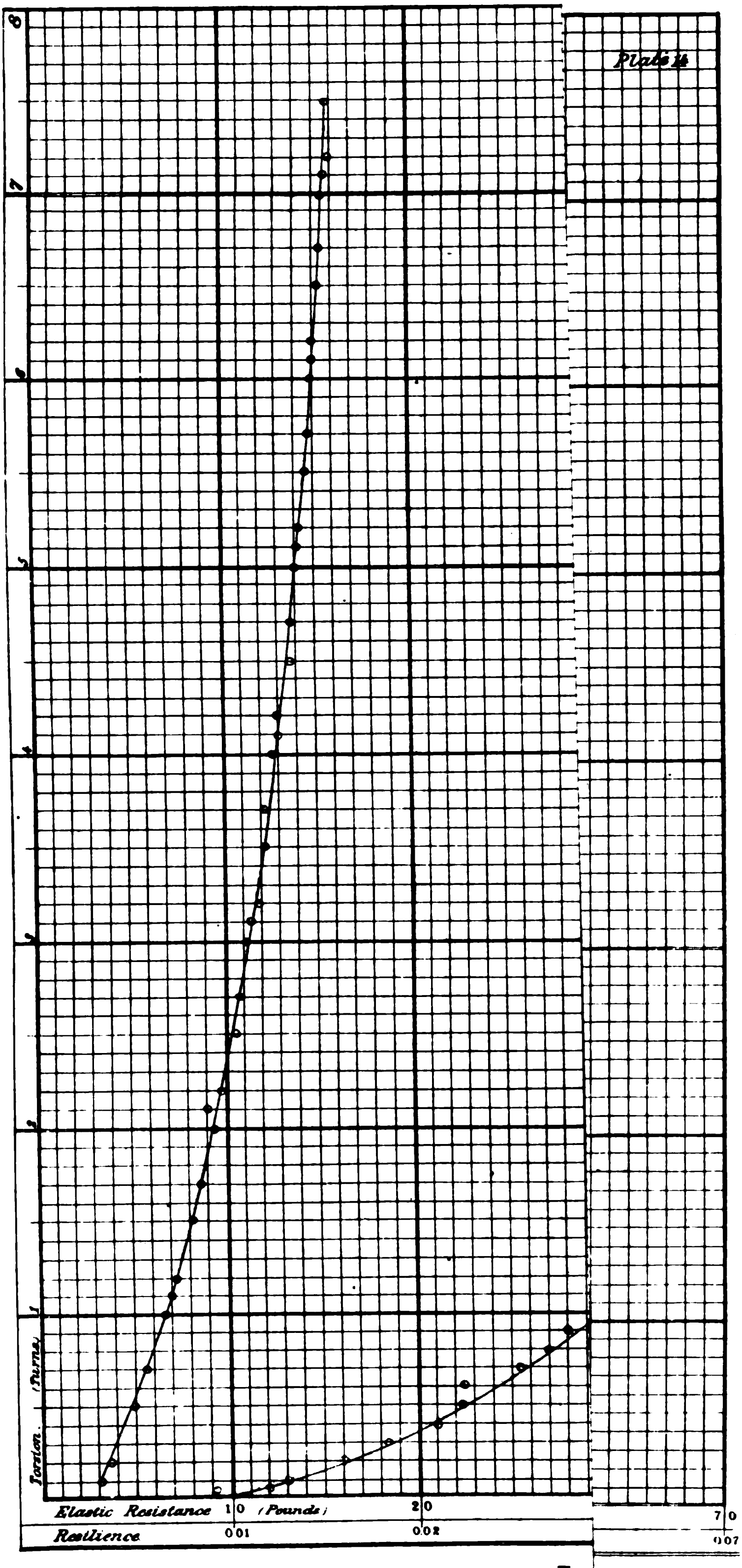
THOGRAPHIC Co N.Y. (OSBORNE'S PROCESS.)

Plate 13.



N.Y. OSBORNE'S PROCESS

Plate 14



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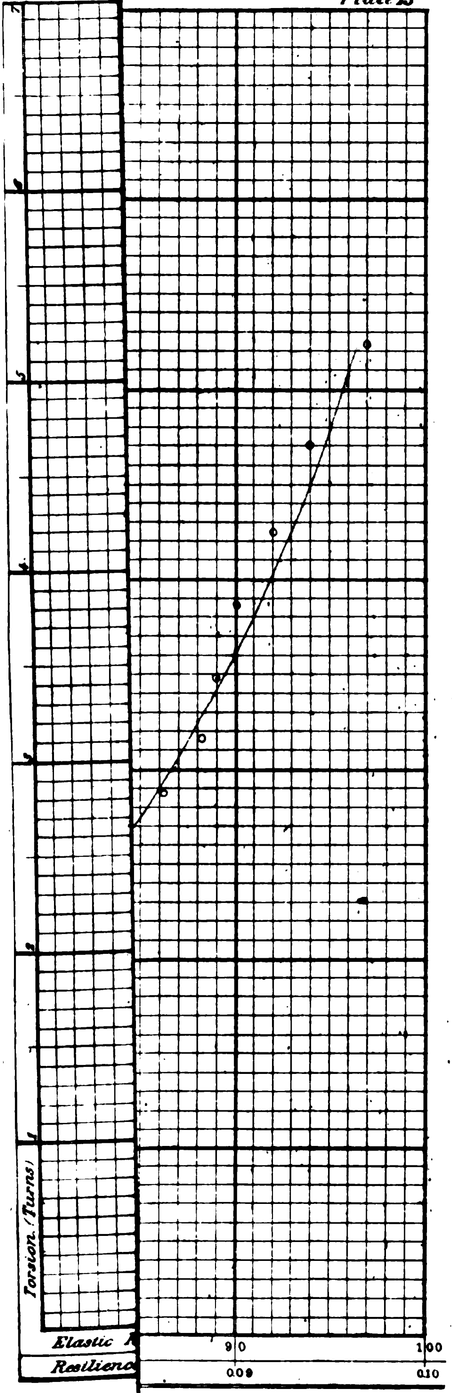
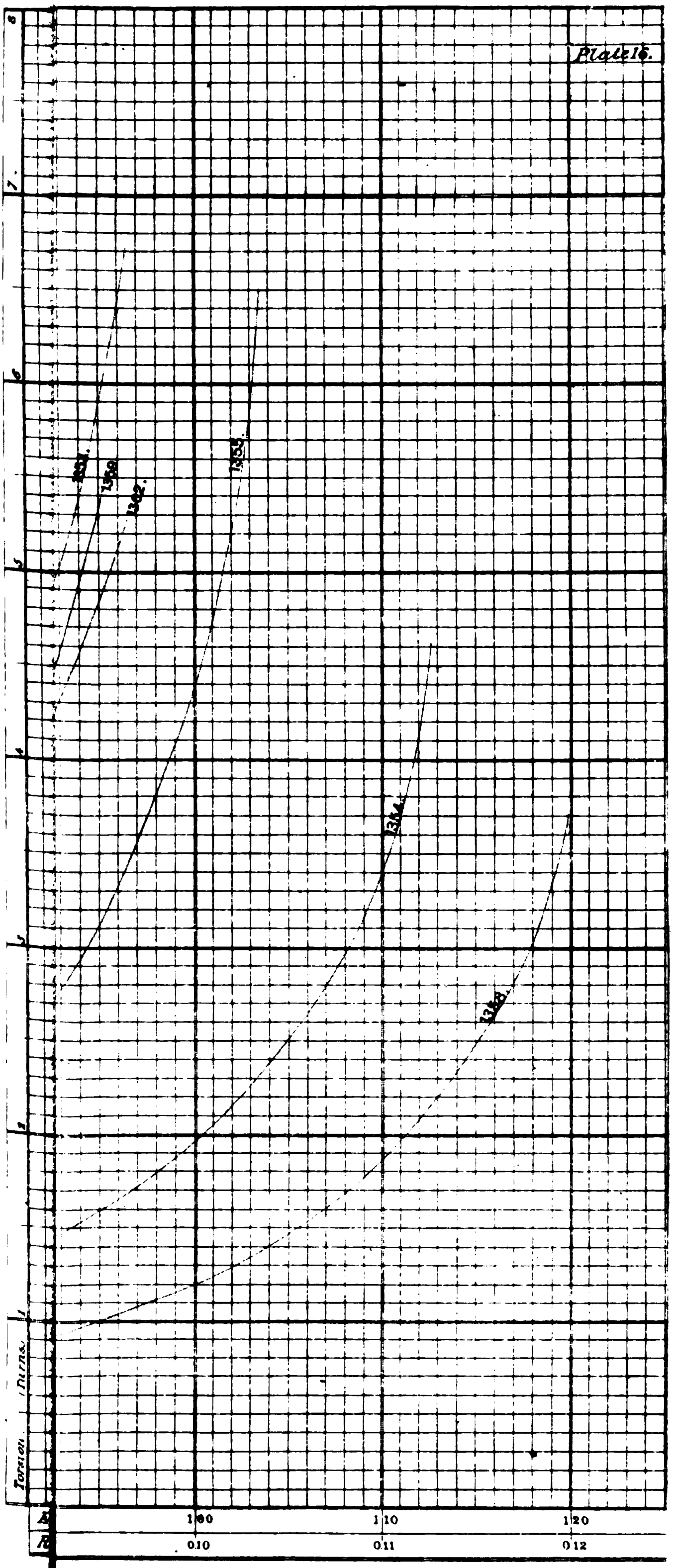
N.Y. OSBORNE'S PROCESS.

Plate 15



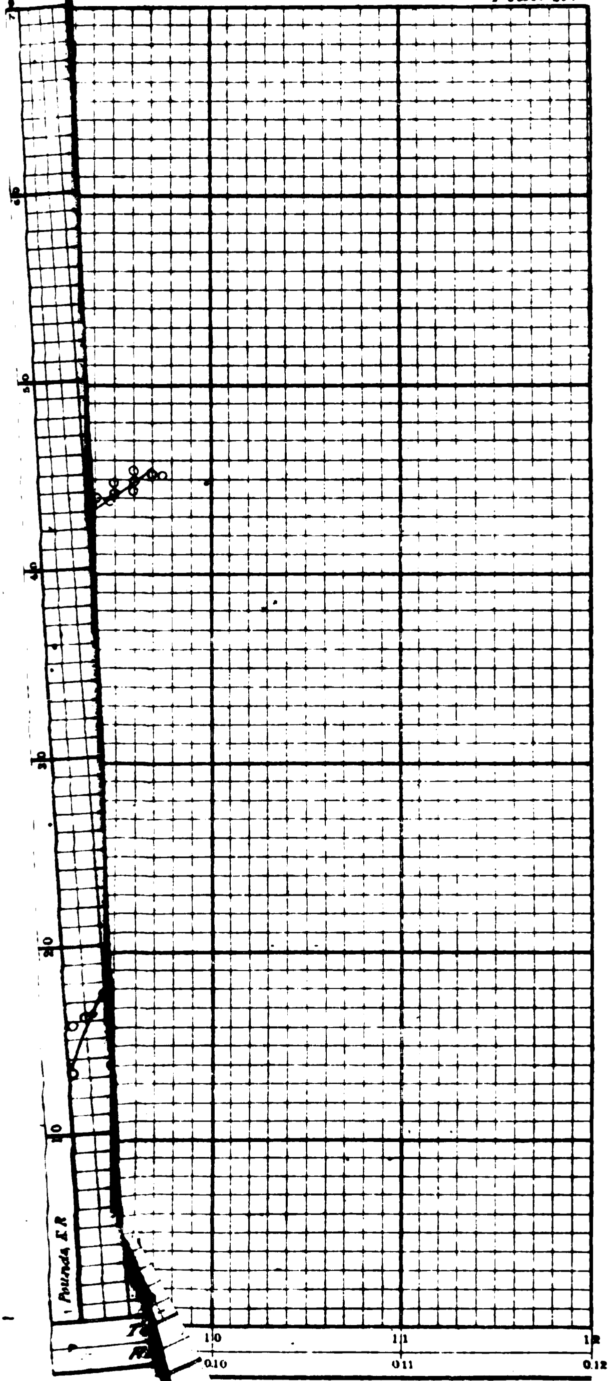
LITHOGRAPHIC Co N.Y (OSBORNES PROCESS)

Plate 16.



AM PHOTO LITHOGRAPHIC Co N.Y. (OSBORNE'S PROCESS)

Plate 17.



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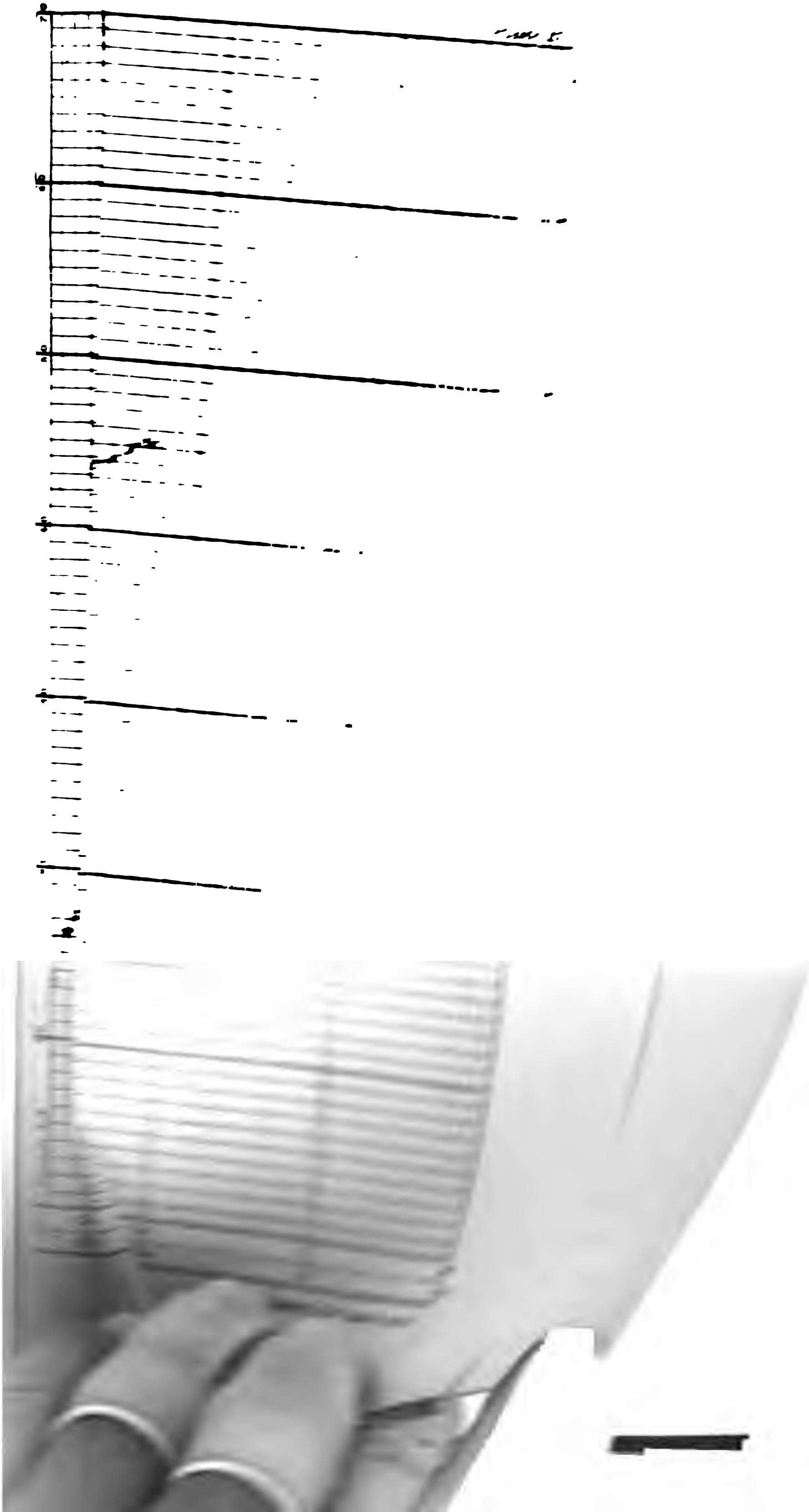
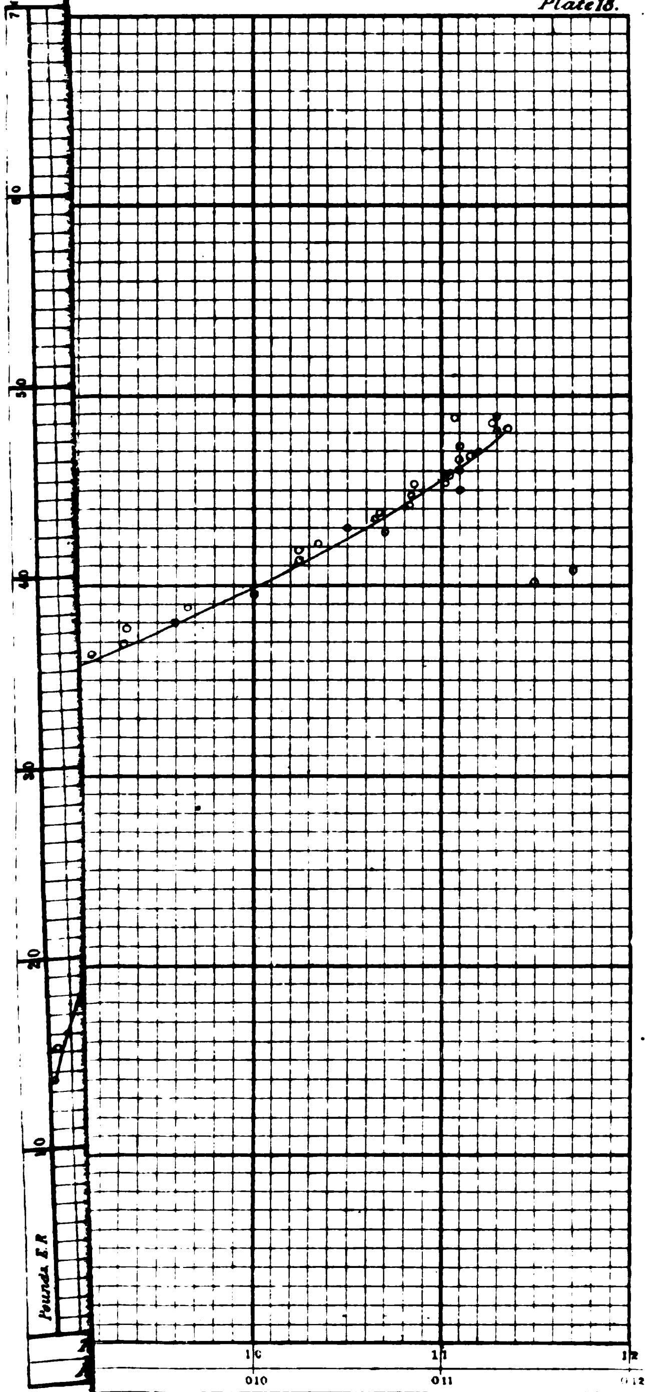
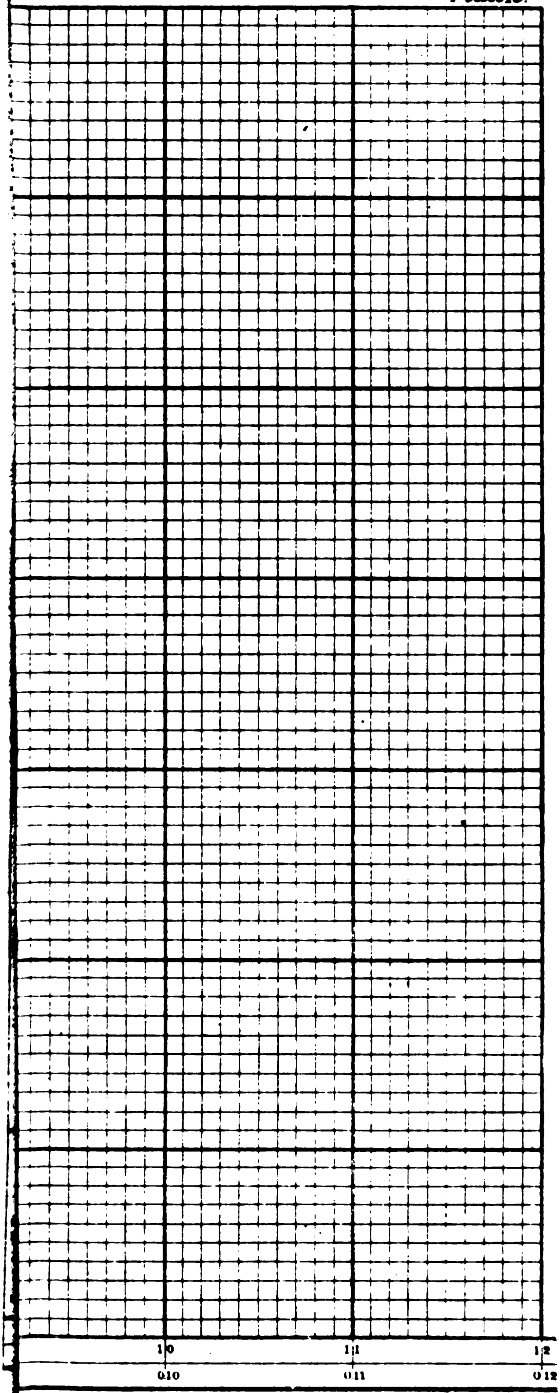


Plate 18.



AM PHOTO LITHOGRAPHIC Co N Y (OSBORNE'S PROCESS)

Plate 10.



AM PHOTO-LITHOGRAPHIC Co N.Y. OSBORNE'S PROCESS

Plate 20.

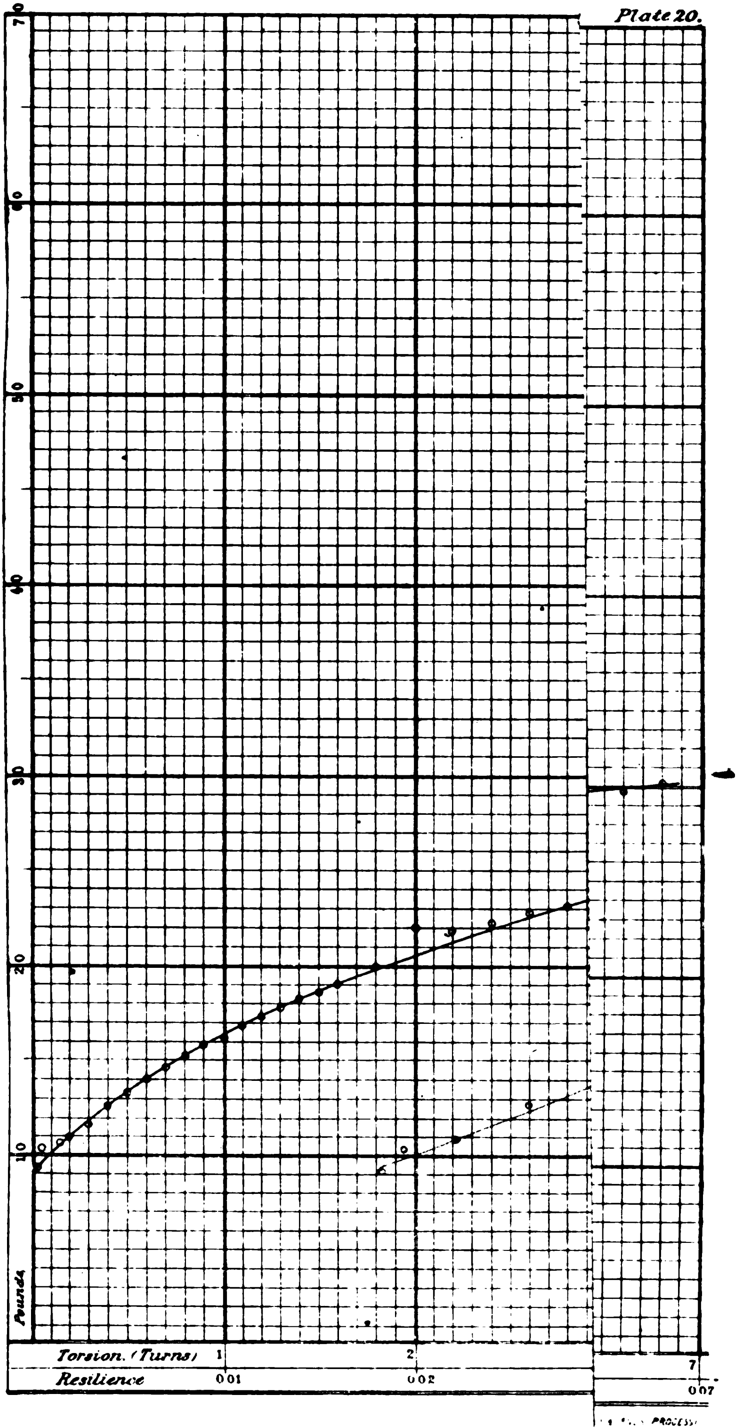


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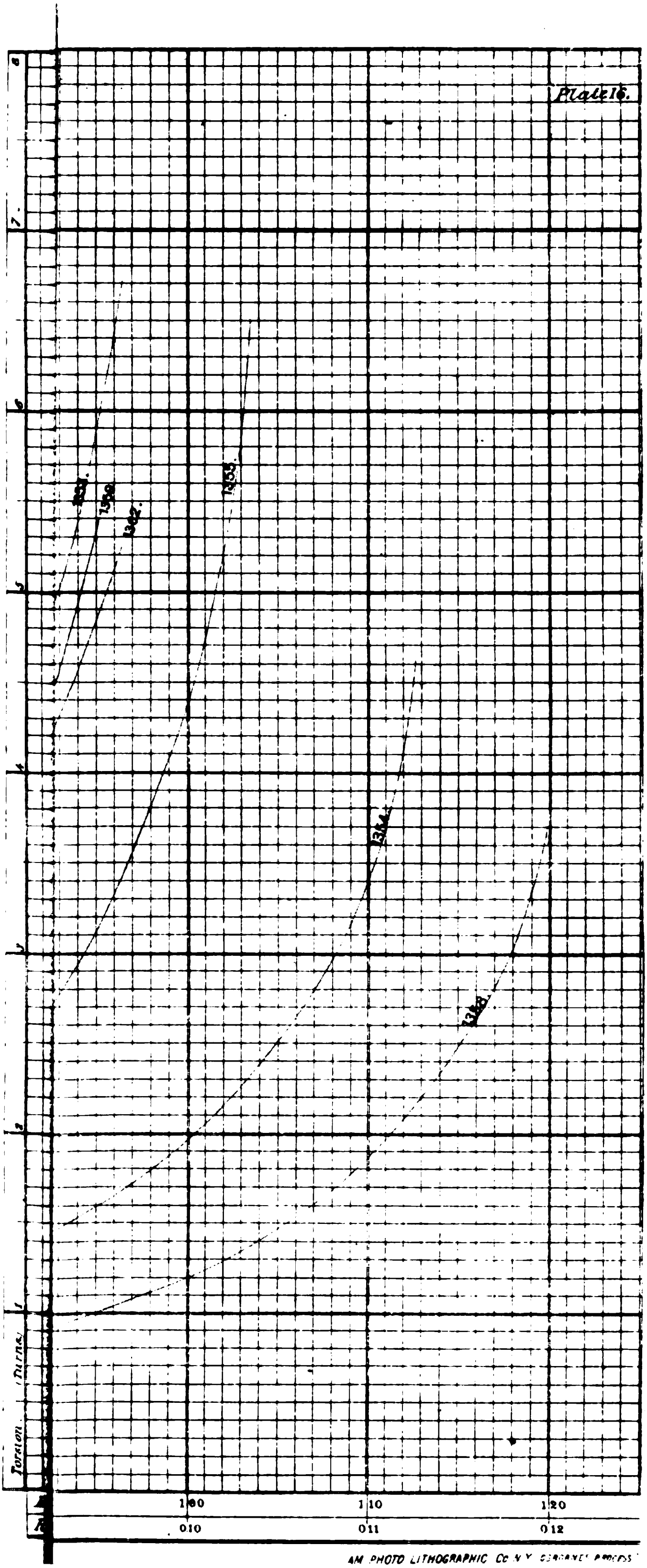
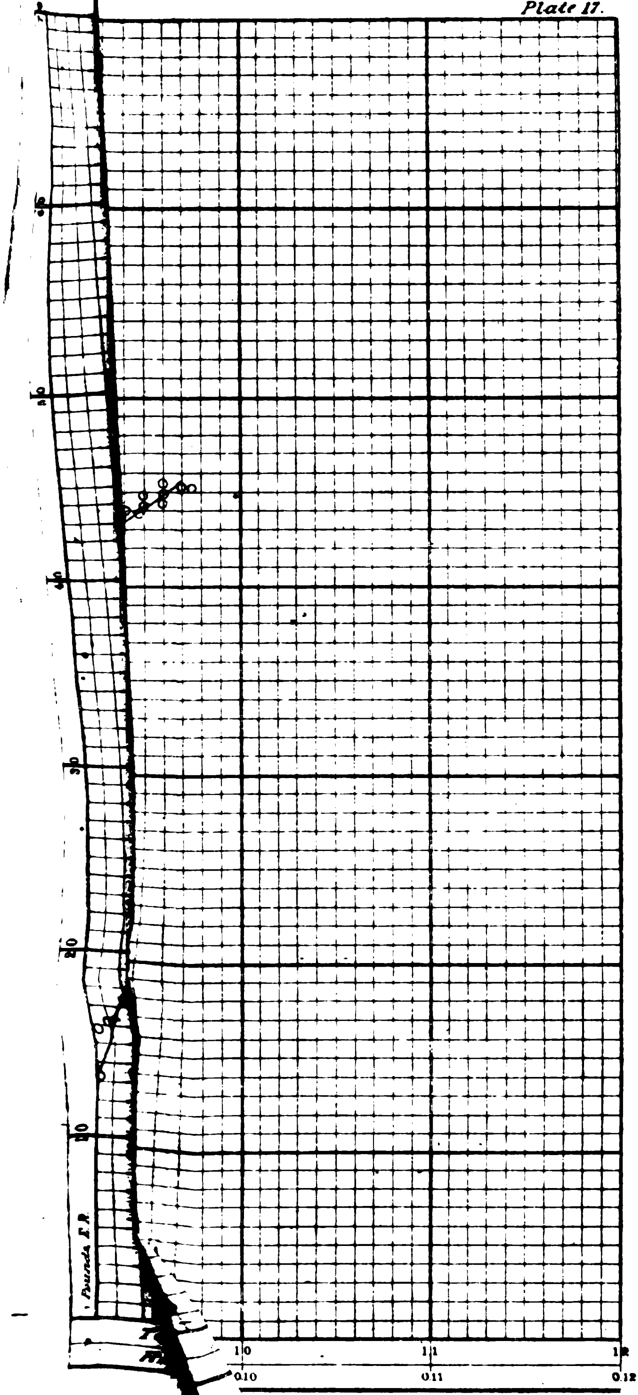
Plate 16.



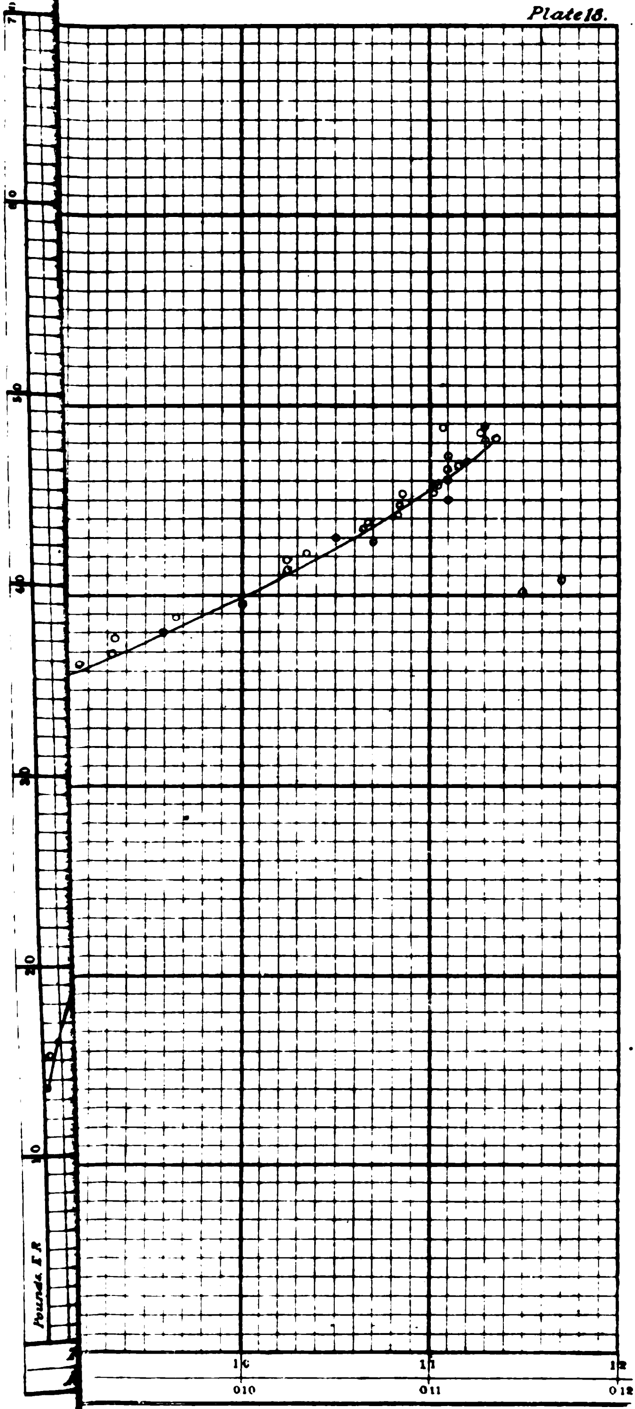
AM. PHOTO LITHOGRAPHIC Co. N.Y. (OSBORNE'S PROCESS)

Plate 17.



AM PHOTO LITHOGRAPHIC Co. N.Y. (OSBORNE'S PROCESS)

Plate 18.



AM PHOTO LITHOGRAPHIC Co N.Y. (OSBORNE'S PROCESS)

Plate 10.

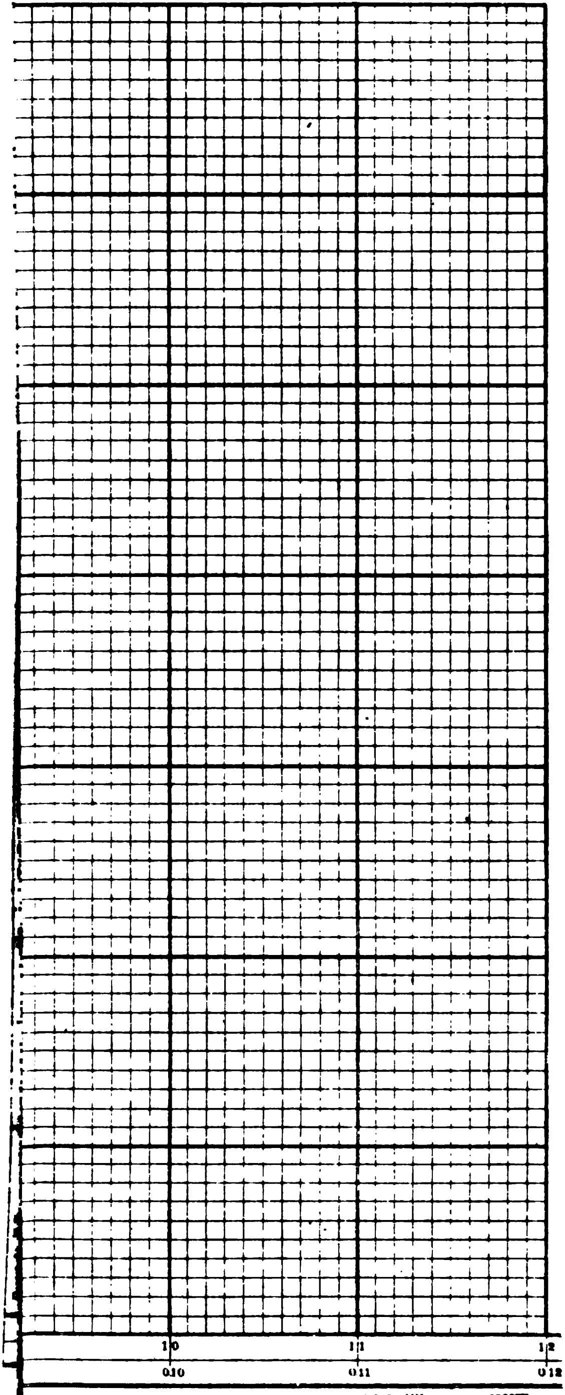


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Plate 20.

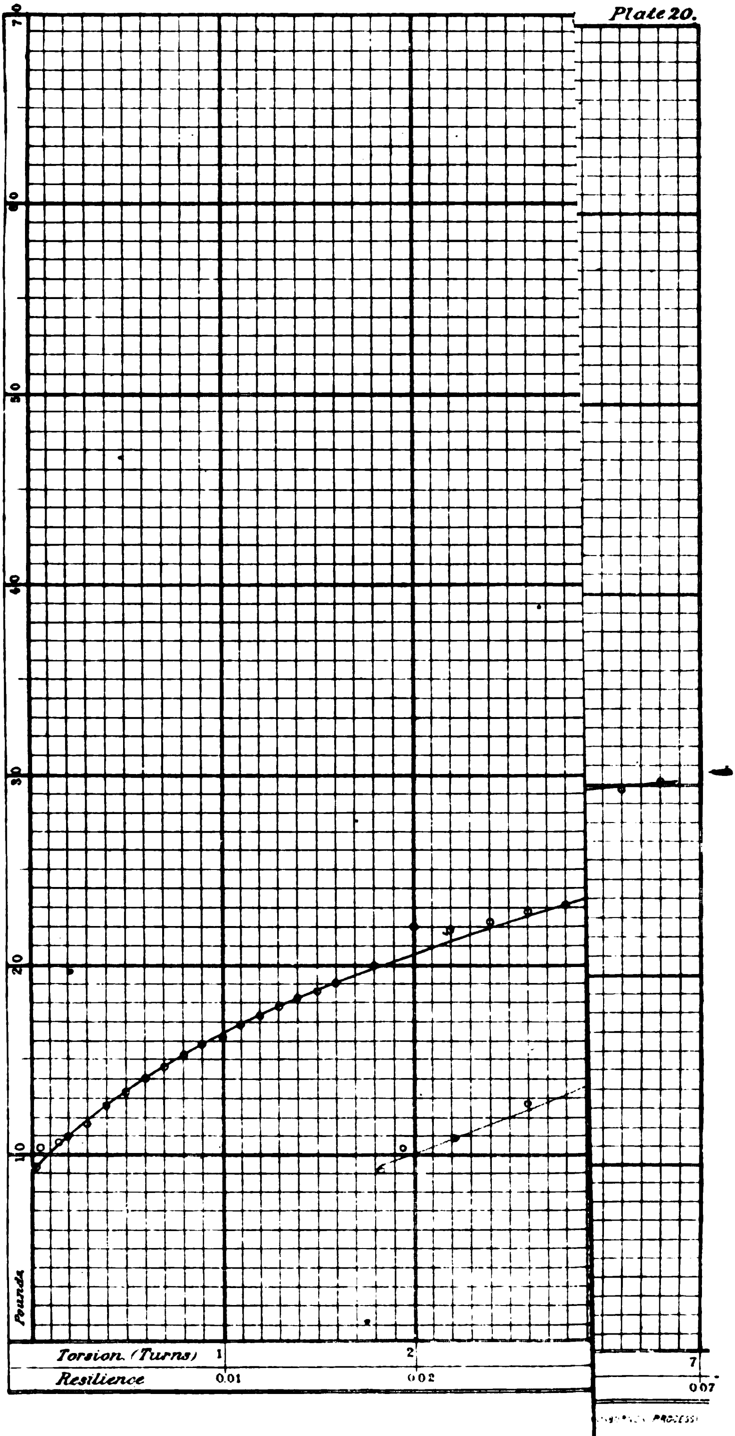

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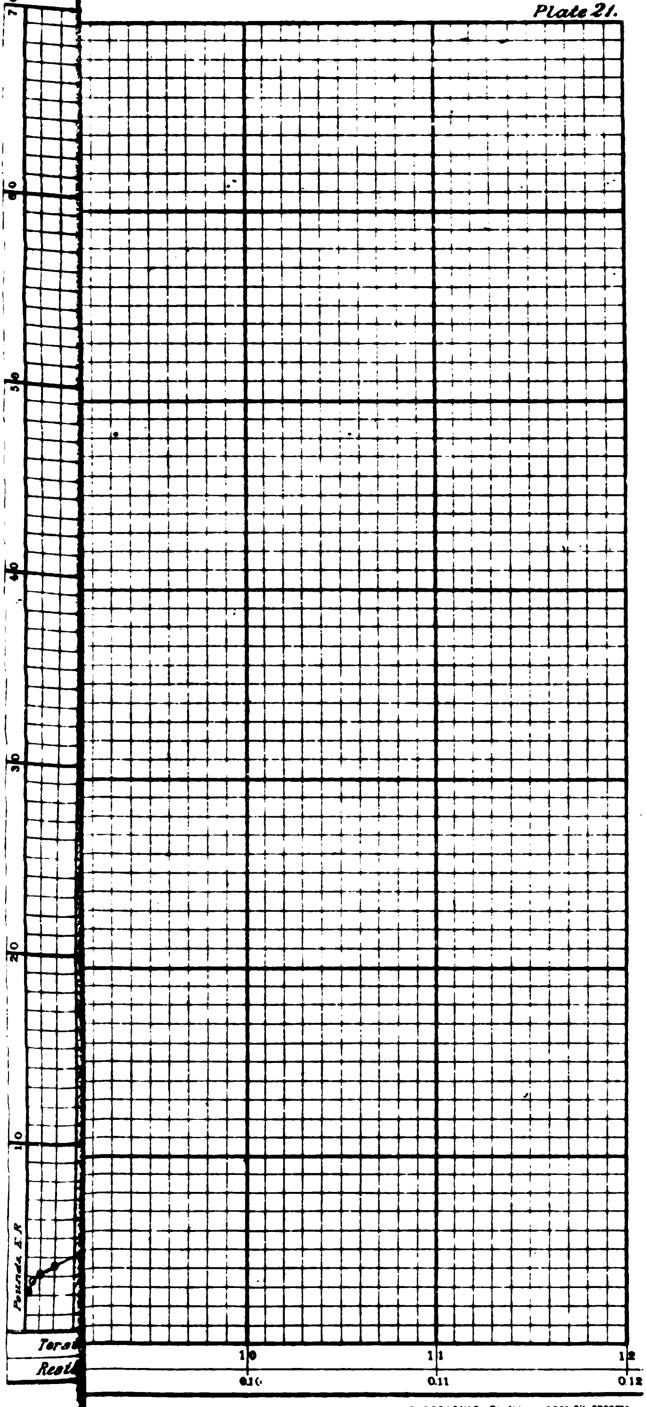
Plate 21.



AM. PHOTO-LITHOGRAPHIC CO. N.Y. OSBORNE'S PROCESS.

Plate 22.

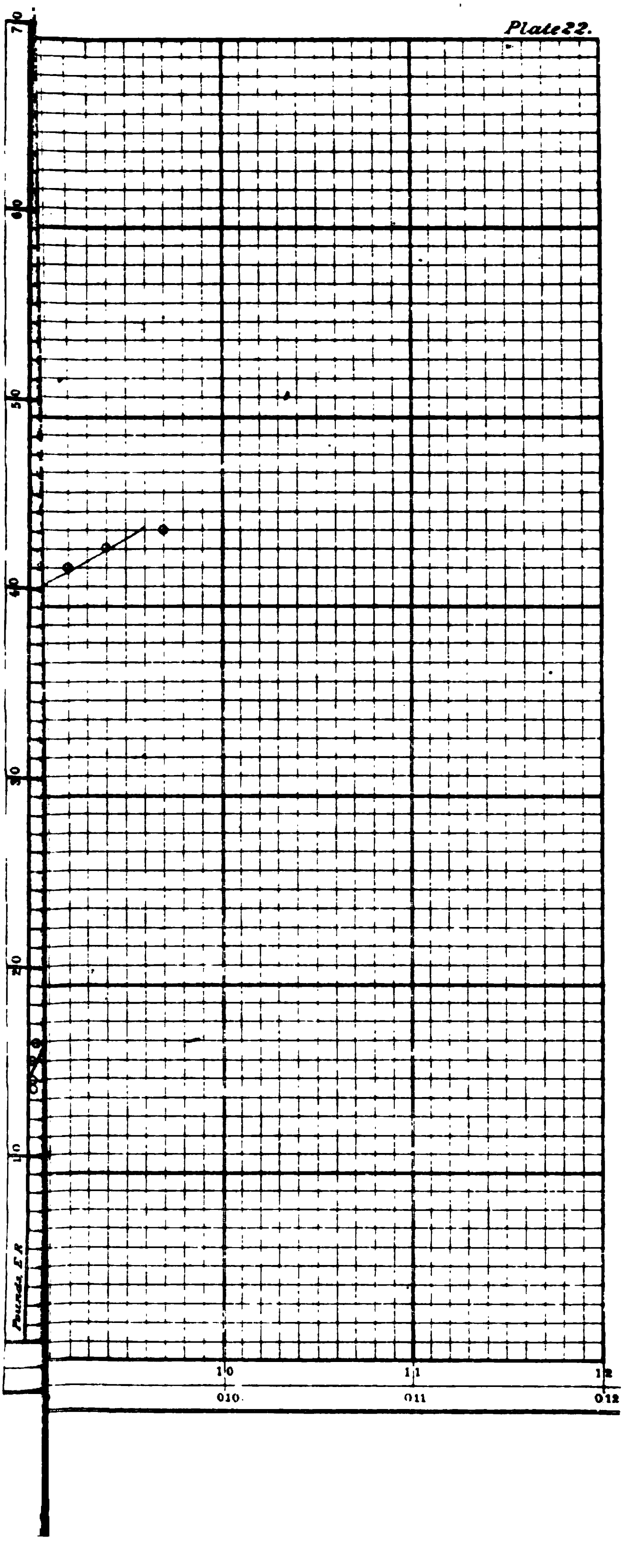
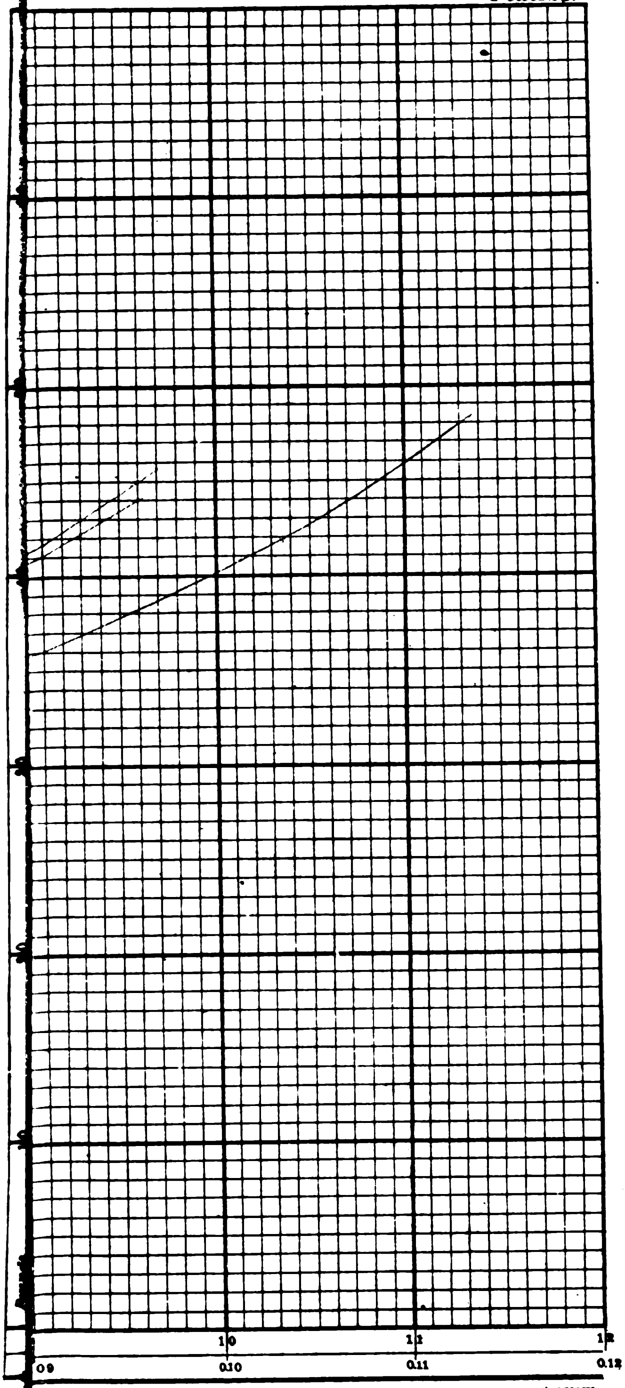
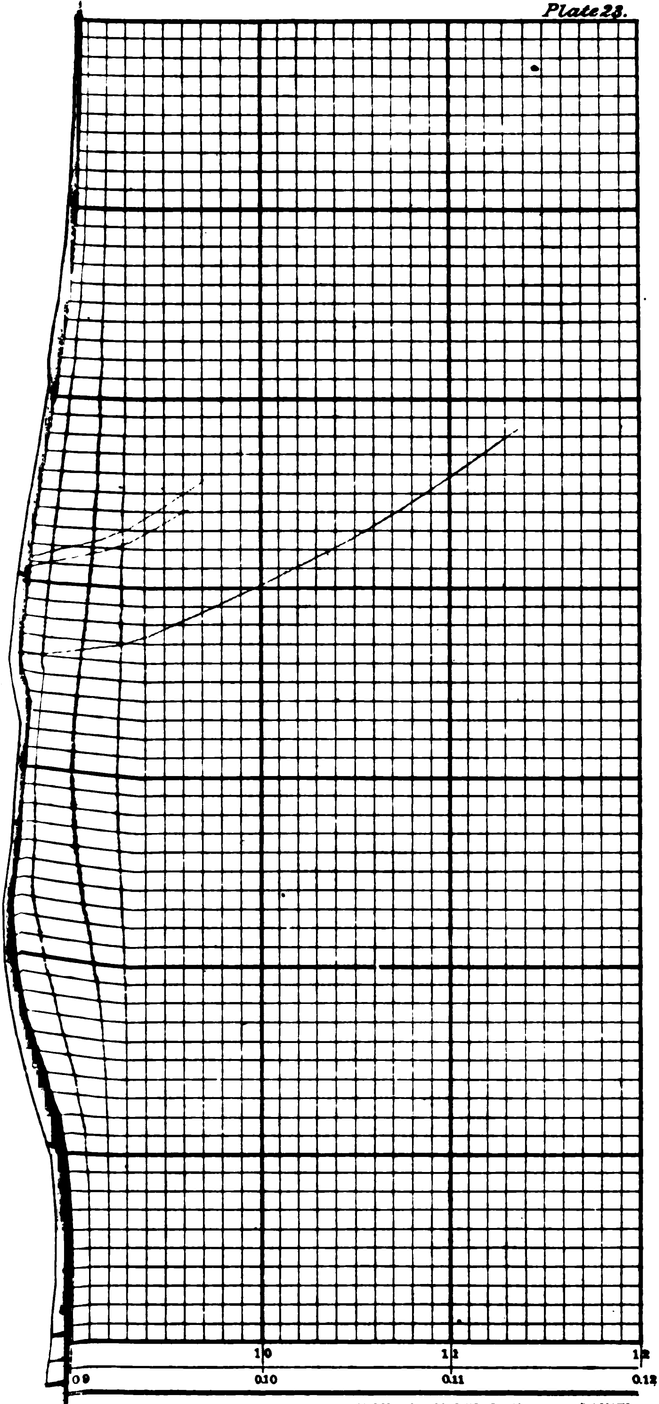


Plate 23.



AM. PHOTO-LITHOGRAPHIC Co. N.Y. (OSBORNE'S PROCESS.)

Plate 23.



AM PHOTO LITHOGRAPHIC Co N.Y. (OSBORNE'S PROCESS)

APPENDIX G.

Statement of the principal articles procured by fabrication at the arsenals and by purchase during the year ending June 30, 1875.

1	3.15-inch breech-loading steel gun.
8	Gatling guns, cal. .45-inch, with appendages.
4	light 6-pounders, carriages and limbers.
1	carriage for 3.15-inch breech-loading gun.
64	carriages and limbers for cal. .45-inch Gatling gun.
13	15-inch gun-carriages, with pneumatic buffers.
1	set implements for 3.15-inch breech-loading gun.
2	breech-sights for 15-inch gun.
67	buckets, assorted.
10	cannon spikes.
4	elevating arcs and indices for 15-inch gun.
19	elevating-bars.
6	fuze-wrenches.
1,850	feed-cases for cal. .45 Gatling gun.
2	gunners' gimlets.
2	pairs gunners' sleeves.
122	handspikes, various.
51	sets harness for Gatling guns, 2-horse.
4	loading-tongs.
74	maneuvering-bars.
4	muzzle-sights.
2	priming-wires for 15-inch gun.
11	rammers and staves for 15-inch gun.
21	pairs shell-hooks.
20	scrapers for guns.
60	securing-stakes.
20	sponge-covers for field and sea-coast guns.
15	sponges and rammers for field-guns.
8	sponges and staves for field and sea-coast guns.
13	paulins.
12	thumb-stalls.
2	tompions for 12-pounder guns.
20	vent-covers.
2	vent-punches for 15-inch guns.
15	vent-pieces.
40	wipers for mortars.
1	worm and staff for siege-gun.
3	Front-sight covers for 1-inch Gatling guns.
53	gun-covers.
100	3-inch shot.
100	3.12-inch shot.
424	8-inch shot.
60	8.4-inch shot.
511	9-inch shot.
387	15-inch shot.
170	3-inch shell.
50	3.9-inch shell.
100	3.15-inch shell.
60	3-inch canister.
10,004	Springfield carbines, cal. .45-inch.

16,253	Springfield rifles, cal. .45 inch.
500	Springfield "cadet" rifles, cal. .45 inch.
143	Lee rifles, cal. .45 inch.
6,400	Colt's revolvers, cal. .45, and appendages.
10,000	trowel-bayonets.
2	officers' swords.
3	cavalry sabers.
2	sets cavalry accouterments.
6,380	carbine-cartridge pouches.
6,796	steel-bayonet scabbards.
10,010	trowel-bayonet scabbards.
3,172	cartridge-boxes.
12	sets infantry equipments.
5,000	gun-slings, lengthened.
62,764	parts of cavalry equipments.
4,289	parts of infantry equipments.
2,409	scabbards for intrenching-tools.
55,936	appendages for Springfield arms.
13	ambulance-saddles.
29,977	cartridge-bags, filled, various.
9,922,076	metallic ball-cartridges.
757,654	metallic blank-cartridges.
25	metallic fuzes.
200	friction-primers.
3,927	pounds powder.
500	signal-shells.
72	blocks, various, for artillery use.
157	chocks, various, for artillery use.
4	gin-falls.
1	gun-lift.
4	gin-handspikes.
10,000	intrenching-tools.
1	hand-cart.
44	rollers, various, for artillery use.
23	shifting-planks.
2	trace-ropes.
10	plane-tables.
23	siege-platforms.
5	shell-racks.
11	skids.
3	sets floor-boards.
13	sets of pneumatic buffers.
1,000	wooden ramrods.
164,604	parts of Springfield arms.
222	pairs of saddle-bags.
7,854	cavalry saddles, covered with leather.
500	fuze-plugs, brass.
1,242	arm-chests.
1,196	packing-boxes.
10,148	small-arm ammunition-boxes.
480	tin cans.
5	tin boxes.
700	copper disks.
1	electric disjunctor.
639	tools, various.
5	velocimeters.

252 pounds fulminate of mercury.
115 gallons lacker.
29,973 pounds paint.
1 bullet-machine.
501 boxes cleaning materials for arms and accouterments.
1 cavalry forge-cart.
3 tool-bags for saddlers and smiths' tools.
60,984 horseshoes.
95,904 pounds horseshoes.
29,435 pounds horseshoe nails.

APPENDIX H.

Statement of ordnance and ordnance stores issued to the Regular Army and to posts during the year ending June 30, 1875.

CLASS I.

2 12-pounder bronze guns, light.
2 12-pounder mountain howitzers.
1 6-pounder bronze gun.
1 4½-inch siege-gun.
2 3-inch rifle-guns.
1 Gatling gun, cal. 1 inch.
5 Gatling guns, cal. .50.
4 Gatling guns, cal. .45.

CLASS II.

19 15-inch barbette gun-carriages and chassis.
1 4½-inch siege-gun carriage, with limber.
1 4½-inch siege-gun carriage, without limber.
2 3-inch gun-carriages, with limbers.
4 12-pounder gun-carriages, with limbers.
2 12-pounder prairie-carriages.
1 6-pounder gun-carriage, with limber.
9 Gatling gun-carriages.
3 Gatling gun-caissons, with limbers.
10 cavalry forges.
1 portable forge.
3 traveling forges, "A," with limbers.

CLASS III.

6 sets of harness for two lead-horses.
6 sets of harness for two wheel-horses.

CLASS IV.

50 8 inch sea-coast howitzer canister.
400 13-inch sea-coast mortar shell.
100 3 inch Eureka case-shot.
40 3-inch Eureka shell.

100	30-pounder Parrott shell.
100	100-pounder Parrott shell.
100	12-pounder shot, unattached.
100	30-pounder Parrott shot.
20	32-pounder shot.

CLASS V.

60	3-inch gun canister.
24	6-pounder gun canister.
258	12-pounder gun canister.
244	12-pounder mountain-howitzer canister.
160	3-inch Hotchkiss case-shot.
52	6-pounder gun case-shot.
580	12-pounder gun case-shot.
252	12-pounder mountain-howitzer case-shot.
300	3-inch Hotchkiss shell.
100	4½-inch Absterdam shell.
368	12-pounder field-gun shell.
508	12-pounder mountain-howitzer shell.
200	3-inch Hotchkiss shot.
20	12-pounder gun shot.

CLASS VI.

243	carbines, Sharps', cal. .50.
27	carbines, Springfield, cal. .50.
3,763	carbines, Springfield, cal. .45.
10	muskets, flint-lock, with whalebone bayonets.
23	muskets, breech-loading, Springfield, cal. .50.
320	rifles, Springfield, cadet, cal. .45.
5,429	rifles, Springfield, cal. .45, with triangular bayonets.
6,774	rifles, Springfield, cal. .45, with trowel-bayonets.
5	rifles, muzzle-loading, cal. .58.
2,750	revolvers, Colt's, cal. .45.
22	revolvers, Colt's, cal. .44.
17	revolvers, Remington, cal. .44.
580	revolvers, Smith & Wesson's, cal. .45.
7	revolvers, Smith & Wesson's, cal. .44.
25	breech-loading shot-guns, double-barrel, No. 10 bore.
1	saber, artillery.
225	sabers, light, cavalry.
48	sabers, light, cavalry, nickel-plated.
28	swords, musicians', leather scabbards.
47	swords, musicians', steel scabbards.
24	swords, non-commissioned officers', leather scabbards.
28	swords, non-commissioned officers', steel scabbards.

CLASS VII.

34	saber-belts, artillery.
18	saber-belt plates, artillery.
2,042	saber-belts, cavalry.
2,011	saber-belt plates, cavalry.
441	saber attachments.
595	saber-knots.
974	carbine cartridge-boxes.

1,561	carbine cartridge-pouches, (Dyer's.)
2,556	carbine-slings.
1,845	carbine-sling swivels.
3,180	pistol-belt holsters.
1,229	pistol cartridge-pouches.
1,252	infantry equipments, sets of, complete.
255	bayonet-scabbards, leather.
329	bayonet-scabbards, steel.
6,811	bayonet-scabbards, trowel.
256	brace-yokes.
11,299	canteens.
211	cap-pouches.
357	cartridge-boxes, cal. .58.
170	cartridge-boxes, No. 1.
271	cartridge-boxes, No. 2.
450	cartridge-boxes for shoulder-belts.
300	cartridge-boxes for waist-belts.
113	cartridge-box plates.
258	cartridge-box belts.
156	cartridge-box belt-plates.
3,080	great-coat straps.
3,080	gun-slings.
8,778	haversacks.
2,722	knapsacks.
898	meat-ration cans.
40	perforated wooden blocks for cartridge-boxes.
57	sword-belts, non-commissioned officers' and musicians'.
52	sword-belt plates, non-commissioned officers' and musicians'.
327	valises.
344	valise-straps.
330	waist-belts, non-commissioned officers' and musicians'.
313	waist-belt plates, non-commissioned officers' and musicians'.
704	waist-belts, privates'.
638	waist-belt plates, privates'.
3,401	bridles, curb.
2,093	bridles, watering.
517	carbine-sockets.
7,028	curry-combs.
2,623	girths.
6,645	halters.
8,447	halter-straps.
10,001	horse-brushes.
8,196	lariats.
1,770	links.
5,029	nose-bags.
3,799	picket-pins.
1,592	saddles.
10	saddles, ambulance.
3,209	saddle-bags.
864	saddle-blankets, artillery.
7,881	saddle-blankets, cavalry.
75	saddle-cloths, felt.
5,304	side-lines.
5,906	spurs.
6,212	spur-straps.
3,748	surcingles.

CLASS VIII.

Ammunition for small-arms.

1,000	blank-cartridges, cal. .69.
150	buck-shot, pounds.
173,040	carbine ball-cartridges, cal. .50.
1,380,200	carbine ball-cartridges, cal. .45.
395,700	carbine and rifle blank-cartridges, cal. .45.
397,680	musket ball-cartridges, cal. .50.
20,474	musket blank-cartridges, cal. .50.
4,500	canister for Gatling gun, cal. 1 inch.
5,250	elongated ball-cartridges for Gatling gun, cal. 1 inch.
300	elongated ball-cartridges, cal. .54.
1,000	musket blank-cartridges, cal .58.
701,500	revolver ball-cartridges, cal. .45.
3,200	revolver ball-cartridges, metallic, cal. .44.
5,859	revolver ball-cartridges, paper, cal. .44.
1,000	revolver ball-cartridges, skin, cal. .44.
28,800	revolver blank-cartridges, metallic, cal. .45.
13,200	revolver blank-cartridges, metallic, cal. .44.
5,000	revolver blank cartridges, paper, cal. .44.
3,021,800	rifle ball-cartridges, cal. .45.
1,000	round ball-cartridges, cal. .54.
5,000	felt wads.

Ammunition for field-guns.

2,850	blank-cartridges, ½-pound charge.
730	blank-cartridges, 1-pound charge.
750	blank-cartridges, 2-pound charge.
4,950	blank-cartridges, 6-pounder gun.
1,000	blank-cartridges, 10-pounder gun.
7,614	blank-cartridges, 12-pounder gun.
6,760	blank-cartridges, 12-pounder mountain howitzer.
1,000	blank-cartridges, 24-pounder howitzer.
7,620	blank-cartridges, 3-inch gun.
90,674	friction-primers.
1,350	fuzes, assorted.
19,200	cannon powder, pounds.
10	Hazard's duck powder, pounds.
3,000	mammoth powder, pounds.
100	mealed-powder, pounds.
19,159	mortar powder, pounds.
800	musket and rifle powder, pounds.
3,000	percussion-caps, pistol.
500	signal shells.

APPENDIX I.

Apportionment of arms for the fiscal year ending June 30, 1875, *under the law of* 1808, *for arming and equipping the militia, as amended by the seventh section of the act approved March* 3, 1855, *and regulations established in conformity therewith.*

States and Territories.	Number of Senators and Representatives.	Money-value.
Alabama	10	$4,797 85
Arkansas	6	2,878 71
California	6	2,878 71
Connecticut	6	2,878 71
Delaware	3	1,439 36
Florida	4	1,919 14
Georgia	11	5,277 64
Illinois	21	10,075 49
Indiana	15	7,196 78
Iowa	11	5,277 64
Kansas	5	2,398 93
Kentucky	12	5,757 42
Louisiana	8	3,838 28
Maine	7	3,358 50
Maryland	8	3,838 28
Massachusetts	13	6,237 21
Michigan	11	5,277 64
Minnesota	5	2,398 93
Mississippi	8	3,838 28
Missouri	15	7,196 78
Nebraska	3	1,439 36
Nevada	3	1,439 36
New Hampshire	5	2,398 93
New Jersey	9	4,318 06
New York	35	16,792 48
North Carolina	10	4,797 85
Ohio	22	10,555 27
Oregon	3	1,439 36
Pennsylvania	29	13,913 76
Rhode Island	4	1,919 14
South Carolina	7	3,358 50
Tennessee	12	5,757 42
Texas	8	3,838 28
Vermont	5	2,398 93
Virginia	11	5,277 64
West Virginia	5	2,398 93
Wisconsin	10	4,797 85
Arizona Territory *	3	1,439 36
Colorado Territory *	3	1,439 36
Dakota Territory *	3	1,439 36
Idaho Territory *	3	1,439 36
New Mexico Territory *	3	1,439 36
Montana Territory *	3	1,439 36
Utah Territory *	3	1,439 36
Washington Territory *	3	1,439 36
Wyoming Territory *	3	1,439 36
District of Columbia *	3	1,439 36
Total	396	189,995 00
Freights, &c	....	11,005 00
		200,000 00

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* Apportionment according to the first paragraph of the President's regulation of April 30, 1855.

APPENDIX K.

Statement of ordnance, ordnance stores, &c., distributed to the militia from July 1, 1874, *to June* 30, 1875, *under the law of* 1808, *as amended by the seventh section of the act approved March* 3, 1855.

4	6-pounder bronze guns.
4	12-pounder bronze guns.
1	Gatling gun, cal. .45 inch, and appendages.
2	Gatling guns, cal. 1 inch, and appendages.
4	6-pounder carriages and limbers.
4	6-pounder carriages and limbers, small.
4	12-pounder carriages and limbers.
1	howitzer carriage and limber, small.
1	carriage and limber for Gatling gun, cal. .45 inch.
2	carriages and limbers for Gatling gun, cal. 1 inch.
2	6-pounder caissons and limbers.
4	12-pounder caissons and limbers.
1	breech-sight.
1	bucket, sponge.
2	buckets, tar.
1	fuze-gouge.
6	gunners' haversacks.
4	gunners' pouches.
3	handspikes, trail.
18	harness, artillery, for 2 wheel-horses, sets.
14	harness, artillery, for 2 lead-horses, sets.
4	implements and equipments for 6-pounder gun, sets.
4	implements and equipments for 12-pounder gun, sets.
2	lanyards.
4	pendulum hausses and pouches.
7	priming-wires.
6	prolonges.
1	sponge-cover.
4	sponges and rammers, 3-inch gun.
2	tarpaulins, 12 by 15 feet.
3	thumb-stalls.
5	tube-pouches.
1	vent-cover.
200	Hotchkiss solid-shot, 3-inch.
200	Hotchkiss shell, 3 inch.
100	Hotchkiss case-shot, 3-inch.
50	Hotchkiss canister, 3-inch.
186	Springfield carbines, cal. .45 inch.
15	Spencer carbines, cal. .50 inch.
150	Springfield rifled muskets, cal. .58 inch.
2,982	Springfield rifles, cal. .45 inch.
2,954	Springfield muskets, cal. .50 inch, model 1868.
80	Springfield "cadet" muskets, cal. .50 inch, model 1869.
1,310	Springfield muskets, cal. .50 inch, model 1870.
449	Remington locking-rifles, cal. .50 inch.
2,693	Colt's revolvers, cal. .45 inch.
20	Schofield-Smith & Wesson revolvers, cal. .45 inch.
655	Smooth-bore, single-barrel pistols, cal. .54 inch.
126	light cavalry sabers.
207	light artillery sabers.

308	non-commissioned officers' swords.
155	artillery saber belts and plates.
86	cavalry accouterments, sets.
195	carbine cartridge-boxes.
625	carbine-slings.
625	carbine-sling swivels.
76	cavalry saber belts and plates.
3,454	infantry accouterments, sets.
280	bayonet-scabbards, leather.
720	bayonet-scabbards, steel.
300	canteens, complete.
200	cartridge-boxes, cal. .58 inch.
360	cartridge-boxes, cal. .50 inch, No. 1.
360	cartridge-boxes, cal. .50 inch, No. 2.
700	gun-slings.
135	non-commissioned officers' shoulder belts and plates.
50	non-commissioned officers' waist belts and plates.
1,125	privates' waist belts and plates.
50	privates' waist-belt plates.
23	brush-wipers and thongs, Spencer's.
12	compound screw-drivers.
364	tompions.
1	set horse-equipments.
2	cavalry curb-bridles.
1,300	cavalry saddles, rawhide-covered.
159	cavalry saddles, leather-covered.
3	saddle-blankets, blue.
50	saddle-blankets, red.
1	saddle-cloth, cotton-duck.
600	cartridge-bags, 3-inch, filled.
10,600	carbine ball-cartridges, cal. .45 inch.
106,000	rifle ball-cartridges, cal. .45 inch.
3,000	rifle blank-cartridges, cal. .45 inch.
102,050	musket ball-cartridges, cal. .50 inch.
5,770	musket blank-cartridges, cal. .50 inch.
12,600	revolver ball-cartridges, cal. .45 inch.
2,300	mortar-powder, pounds.
3,400	friction-primers.
2	leg-guards.
8	pole-pads.
14	pole-straps, pairs.
10	saddles, artillery, drivers'.
2	sponge-staves.
10	whips, artillery.
1	worm and staff.
278	spare parts for Springfield musket, cal. .50 inch.

APPENDIX L.

Statement of ordnance, ordnance stores, &c., distributed to the colleges from July 1, 1874, *to June* 30, 1875, *under the joint resolution of May* 4, 1870.

4	6-pounder bronze guns.
4	light 12-pounder bronze guns.

4	6-pounder gun-carriages and limbers.
4	12-pounder gun-carriages and limbers.
4	6-pounder gun-caissons and limbers.
4	12-pounder gun-caissons and limbers.
4	sets of implements and equipments for 6-pounder gun.
4	sets of implements and equipments for 12-pounder gun.
4	tarpaulins, 12 by 15 feet.
150	Springfield rifled muskets, cal. .50, model 1868.
638	Springfield rifled "cadet" muskets, cal. .50, model 1869.
49	musicians' swords.
75	non-commissioned officers' swords.
788	bayonet-scabbards.
788	carbine cartridge-boxes.
52	shoulder belts and plates, non-commissioned officers'.
20	waist belts and plates, non-commissioned officers'.
788	waist belts and plates, privates.
20	sliding-frogs for waist-belts.
2,000	carbine ball-cartridges, cal. .50 inch.
1,100	carbine blank-cartridges, cal. .50 inch.
2,000	"cadet" musket ball-cartridges, cal. .50 inch.
100	friction-primers.

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